CHAPTER 4

PLUMBING VALVES AND ACCESSORIES

LEARNING OBJECTIVE: *Recognize types of valves, accessories and their use, methods of installation, maintenance, and repair.*

In this chapter, you are provided information regarding types of valves and procedures for installing and repairing them, valve accessories, and pipe fittings. Also discussed are testing of systems, erecting shoring and scaffolding, and laying out wastewater systems, and water distribution systems.

VALVES

LEARNING OBJECTIVE: *Recognize types of valves and methods of valve repair.*

Flexibility in the operation of a water-supply system requires the proper valves for the condition that is to be controlled. Valves are used to stop, throttle, or control the flow of water in a pipeline. Other uses include pressure and level control and proportioning flow. A number of different valve designs are used by a Utilitiesman. In this section, different types of valves, their purpose, and maintenance and repair of valves are presented.

GATE VALVE

The gate valve (fig. 4-1) is used in systems where a straight flow with the least amount of restriction is needed. These valves are used in steam lines, waterlines, fuel oil lines, and fire-main cutouts.

The part of a gate valve that opens or closes the valve flow is known as the GATE. The gate is normally wedge-shaped; however, some are uniform in thickness throughout. When the gate is wide open, the opening through the valve is equal to the size of the piping in which the valve is installed; therefore, there is little resistance in the flow of the liquid. Since regulating the flow of liquid is difficult and could cause extensive damage to the valve, the gate valve should NOT be used as a throttling valve. The gate valve should be left in one of two positions-completely open or closed.

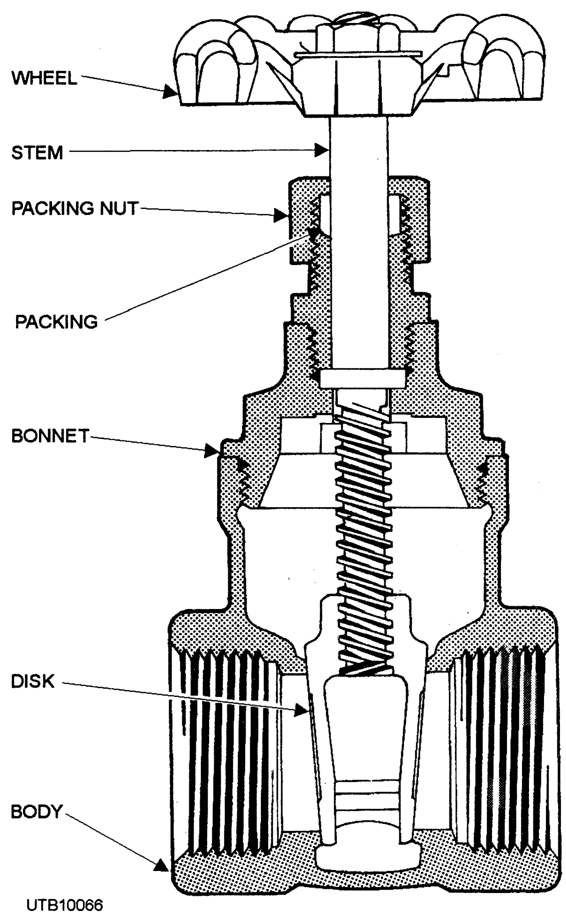


Figure 4-1.—Gate valve.

Figure 4-1 shows a cross-sectional view of a gate valve. The gate is connected to the valve stem. Turning of the handwheel raises or lowers the valve gate. Some gate valves have NONRISING STEMS. On these, the stem is threaded on the lower end, and the gate is threaded on the inside; therefore, the gate travels up the stem when the valve is being opened. This type of valve usually has a pointer or a gauge to indicate whether the valve is in the OPEN or in the CLOSED position. Some gauge valves have RISING STEMS. In these valves, both the gate and the stem move upward when the valve is opened. In some rising stem valves, the stem projects above the handwheel when the valve is opened. The purpose of the rising stem is to allow the operator to see whether the valve is opened or closed.

GLOBE VALVE

The name is derived from the globular shape of the valves; however, other types of valves may also have globe-shaped bodies, so do not jump to the conclusion that a valve with a globe-shaped body is actually a globe valve. The internal structure of a valve, not the external shape, is what distinguishes one type of valve from another.

In a globe type of stop valve, the disk is attached to the valve stem. The disk seats against a seating ring or a seating surface that shuts off the flow of fluid. When the disk is removed from the seating surface, fluid can pass through the valve in either direction. Globe valves may be used partially open as well as fully open or fully closed.

The fluid flow is proportionate to the number of turns of the wheel in opening or closing the globe valve. The globe valve is ideal for service that requires frequent valve settings (throttling).

Globe valve inlet and outlet openings are arranged in several ways to satisfy different requirements of flow.

Figure 4-2 shows three common types of globe valve bodies. In the straight type, the fluid inlet and outlet openings are in line with each other. In the angle type, the inlet and outlet openings are at an angle to each other. An angle type of globe valve is commonly used where a stop valve is needed at a 90-degree turn in a line. The cross type of globe valve has three openings, rather than two; it is frequently used in connection with bypass lines.

Globe valves are commonly used in steam, air, oil, and waterlines. In many boiler plants, there are surface blow valves, bottom blow valves, boiler stops, feed stop valves, and many guarding valves and line cutout valves. Globe valves are also used as stop valves on the suction side of many fireroom pumps as recirculating valves in the fuel oil system and as throttle valves on most fireroom auxiliary machinery. A cross-sectional view of a globe valve is shown in figure 4-3.

BUTTERFLY VALVE

The butterfly valve (fig. 4-4) in certain applications has some advantages over gate and globe valves. The butterfly valve is light in weight, takes up less space than a globe valve or gate valve, is easy to overhaul, and can be opened or closed quickly.

The design and construction of butterfly valves may vary, but a butterfly type of disk and some means of sealing are common to all butterfly valves.

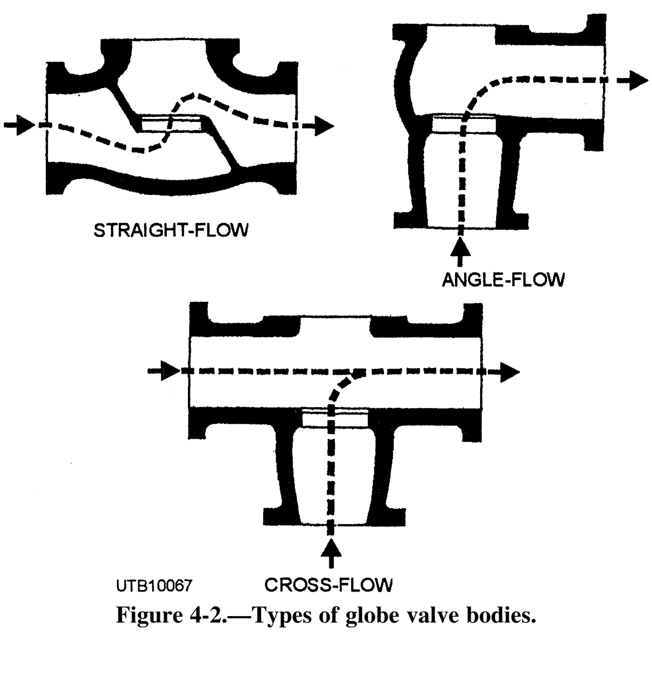


Figure 4-2.—Types of globe valve bodies.

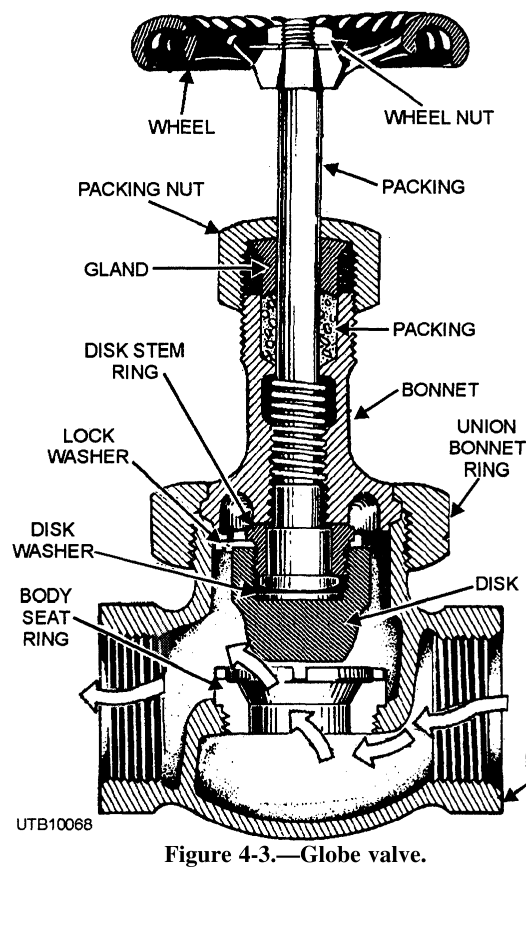


Figure 4-3.—Globe valve.

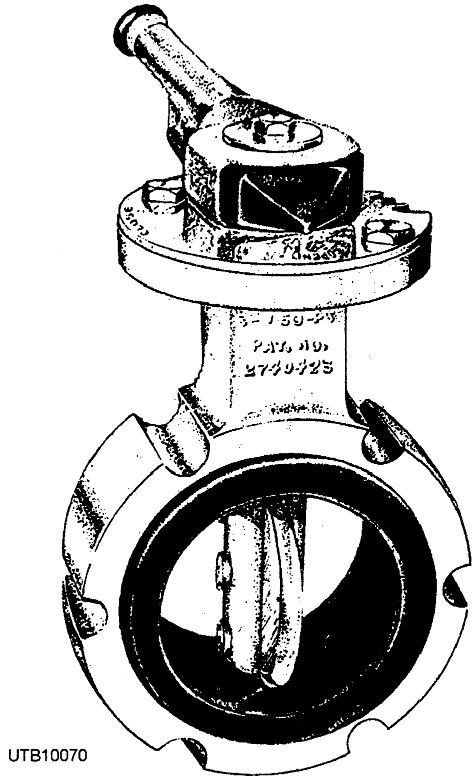


Figure 4-4.—Butterfly valve.

The butterfly valve shown in figure 4-4 consists of a body, a resilient seat, a butterfly type of disk, a stem, packing, and a notched positioning plate and handle. The resilient seat is under compression when it is mounted in the valve body. The compression causes a seal to form around the edge of the disk and both upper and lower points where the stem passes through the seat. Packing is provided to form a positive seal around the stem if the seal formed by the seat is damaged.

To close the valve, turn the handle a quarter of a turn to rotate the disk 90 degrees. The resilient seat exerts positive pressure against the disk, which assures a tight shutoff. The larger size butterfly valves have electrical or mechanical gear-driven mechanisms to open or close the valve.

Butterfly valves are easy to maintain. The resilient seat is held in place by mechanical means; therefore, neither bonding nor cementing is necessary. Since the resilient seat is replaceable, the valve seat does not require any lapping, grinding, or machine work.

Butterfly valves serve a variety of requirements. These valves are now being used in salt water, fresh water, JP-5 fuel, naval distillate fuel oil, diesel oil, lubricating oil systems, and air ventilation systems.

CHECK VALVE

Check valves permit liquids to flow through a line in one direction only; for example, they are used in drain lines where it is important that there is no backflow. Considerable care must be taken to see that valves are installed properly. Most of them have an arrow, or the word *inlet,* cast on the valve body to indicate direction of flow. If not, you must check closely to make sure the flow of the liquid in the system operates the valve in the proper manner.

The port in a check valve may be closed by a disk, a ball, or a plunger. The valve opens automatically when the pressure on the inlet side is greater than that on the outlet side. They are made with threaded, flanged, or union faces, with screwed or bolted caps, and for specific pressure ranges.

The disk of a SWING-CHECK valve (fig. 4-5) is raised as soon as the pressure in the line below the disk is of sufficient force. While the disk is raised, continuous flow takes place. If for any reason the flow is reversed or if back pressure builds up, this opposing pressure forces the disk to seat, which, in turn, stops the flow. Swing-check valves are used in horizontal lines and have a small amount of resistance to flow.

The operation of a LIFT-CHECK valve (fig. 4-6) is basically the same as that of the swing-check valve. The difference is the valve disk moves in an up-and-down direction instead of through an arc. Lift-check valves are used in lines where reversal of flow and pressures are changing frequently. This valve does not chatter or slam as the swing-check valve does, but it does cause some restriction of flow.

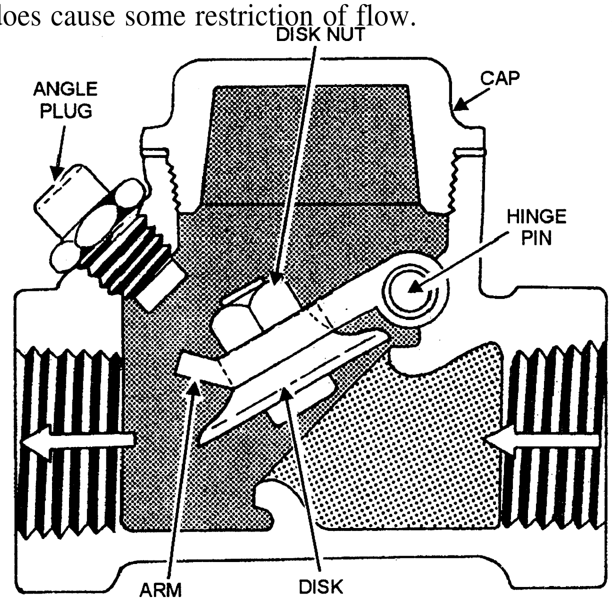


Figure 4-5.—Swing-check valve.

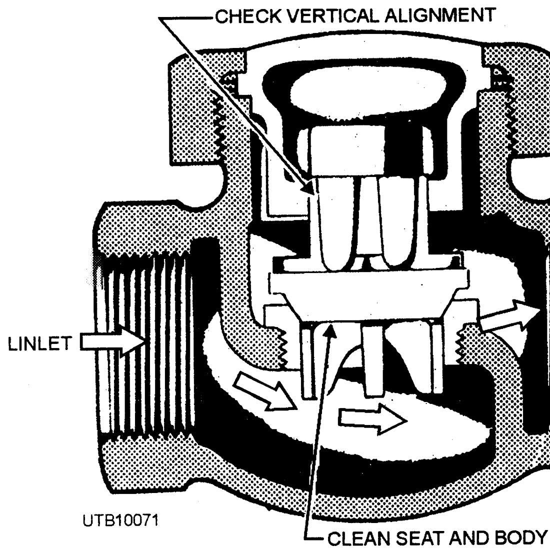


Figure 4-6.—Lift-check valve.

Ball-check valves handle viscous fluids and are very efficient in lines that contain scale and other debris. Because the ball-check valve operates quietly, it is recommended for use in lines that contain fluids where pressure changes rapidly.

STOP-CHECK VALVE

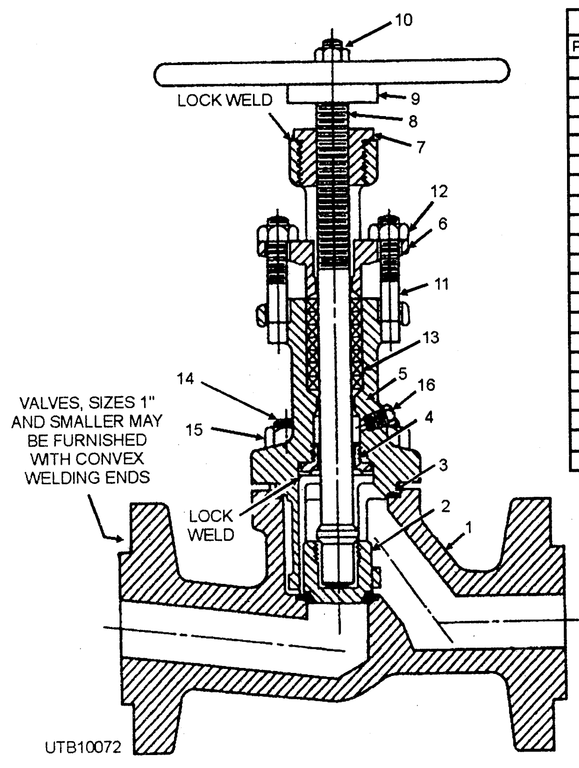
As we have seen so far, most valves are classified as either stop valves or check valves; however, some valves function either as a stop valve or as a check valve, depending upon the position of the valve stem. These valves are known as STOP-CHECK VALVES.

The cross section of two stop-check valves is shown in figure 4-7. As you can see, this type of valve looks much like a lift-check valve. The valve stem is long enough so when it is screwed all the way down, it holds the disk firmly against the seat, thereby preventing the flow of any fluid. In this position, the valve acts as a stop valve. When the stem is raised, the disk can then be opened by pressure on the inlet side. In this position, the valve acts as a check valve and allows the flow of fluid in one direction only. The amount of fluid allowed to pass through is regulated by the opening. The opening is adjusted by the stem.

PRESSURE-REDUCING VALVE

Pressure-reducing valves are automatic valves used to provide a steady pressure lower than that of the supply pressure. Pressure-reducing valves can be set for any desired discharge pressure that is within the limits of the design.

Several types of reducing valves are used in the Navy; however, you will be working mostly with those in the water service system. These are normally single-seated, direct-acting, and spring-loaded, as shown in figure 4-8. Water passing through this valve



LIST OF PARTS

PART NO.	NAME OF PART
1	BODY
2	DISK
3	GASKET
4	STEM BUSHING
5	BONNET
6	GLAND
7	YOKE BUSHING
8	STEM
9	HANDWHEEL
10	HANDWHEEL NUT
11	GLAND BOLT
12	GLAND BOLT NUT
13	PACKING
14	BONNET STUD
15	BONNET STUD NUT
16	RELIEF PLUG
17	SEAT RING
18	SPACER
19	GLAND FLANGE
20	YOKE BUSHING SETSRCEW
21	JAMB NUT

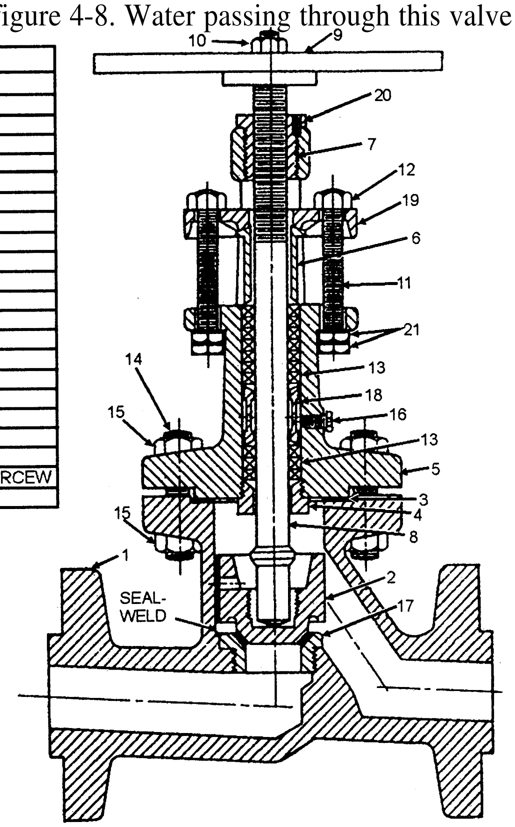


Figure 4-7.—Step-check valve.

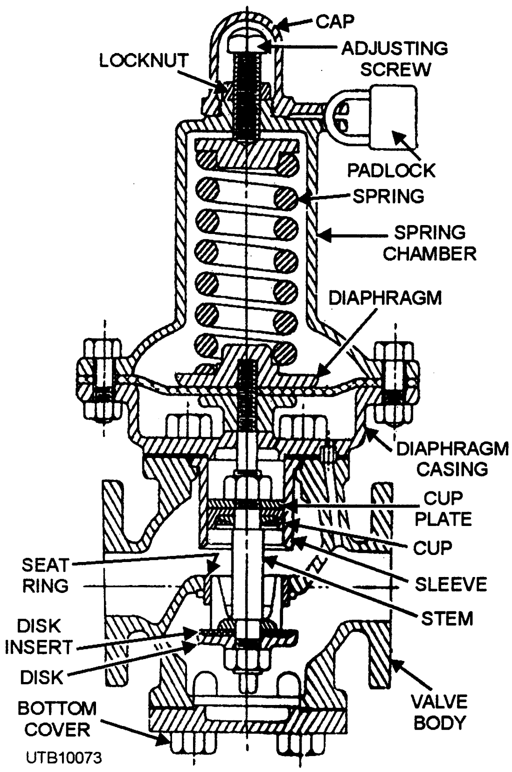


Figure 4-8.—Spring-loaded diaphragm type of pressure-reducing valve.

is controlled by means of a pressure difference on both sides of the diaphragm. The diaphragm is secured to the stem. Reduced water pressure from the valve outlet is then led through an internal passage to a diaphragm chamber located below the'diaphragm. An adjusting spring acts on the upper side of the diaphragm. A leather cup washer or a neoprene O ring makes the water seal between the valve inlet and the diaphragm chamber. This seal is located halfway down the valve stem.

The amount of water pressure applied to the underside of the diaphragm varies according to the discharge pressure. When the discharge pressure is greater than the spring pressure, the diaphragm is forced up. Since this is an upward-seating valve, the upward movement of the stem tends to close the valve or at least to decrease the amount of discharge. When the discharge pressure is less than that of the spring pressure, the diaphragm and the valve stem are forced down, opening the valve wider and increasing the amount of discharge. When the discharge pressure is equal to the spring pressure, the valve stem remains stationary and the flow of water through the valve is not changed.

The amount of pressure applied by the spring to the top of the diaphragm can be adjusted by turning an adjusting screw. Turning the adjusting screw CLOCKWISE increases the pressure applied by the spring to the top of the diaphragm, which, in turn, opens the valve. Turning the adjusting screw COUNTERCLOCKWISE decreases the amount of spring pressure on top of the diaphragm, which, in turn, decreases the amount of discharge. Opening and closing of the valve continues as long as the discharge pressure fluctuates.

Figure 4-9 shows a different type of spring-loaded pressure-reducing valve. In this valve, water enters on the inlet side and acts against the main valve disk, tending to close the main valve; however, water pressure is also led through ports to the auxiliary valve, which controls the admission of water pressure to the top of the main valve piston. This piston has a larger surface than the main disk; therefore, a relatively small amount of pressure acting on the top of the main valve piston tends to open the main valve and also allow water at reduced pressure to flow out the discharge side.

PRESSURE-RELIEF VALVE

This type of valve discharges water from pipes or systems when the maximum desired pressure is exceeded. Normally, the valve starts to open at the set pressure and continues to open gradually until the

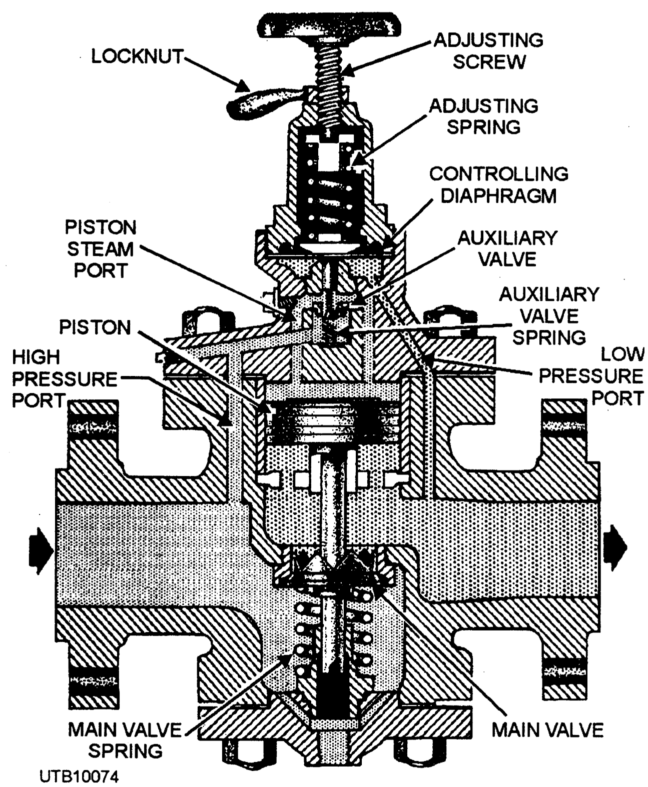


Figure 4-9.—Spring-loaded pressure-reducing valve.

pressure has reached 20 percent above the set pressure, then the valve opens completely. Pressure-relief valves are installed on low-pressure systems fed through pressure-reducing valves from high-pressure supplies to ensure against damage if the pressure-reducing valves fail to operate. Pressure-relief valves are also used on pump headers, discharging into large supply mains to relieve the high-surge pressure that builds up between the time a pump is started and the time required for water in the main to reach full velocity. Relief valves are essentially pressure-reducing valves in which the control mechanism responds to pressure on the inlet, rather than the outlet, end.

HYDRAULIC CONTROL VALVE

Hydraulic control valves are used in many sprinkler systems. On some stations, they are installed in the sections of fire main that supply water to the magazine sprinkling system. This type of valve may be operated from one or more remote control stations by a hydraulic control system.

The hydraulic control valve shown in figure 4-10 is a piston-operated globe valve. It is normally held in the CLOSED position by both a spring force and by the fire-main pressure acting against the disk. When hydraulic pressure is admitted to the underside of the piston, a force is created that overcomes both the spring tension and the fire-main pressure, thereby causing the valve to open.

When hydraulic pressure is released from under the piston, the spring acts to force the hydraulic fluid out of the cylinder and back to the remote control station, thus closing the valve.

A ratchet lever is fitted to the valve so in an emergency, the valve can be opened by hand. After the valve has been opened by hand, you should first restore the stem to its normal CLOSED position with the ratchet lever. Then, line up the hydraulic system from a remote control station, so the hydraulic fluid in the valve cylinder can return to the storage tank at the control station. The full force of the closing spring acts to seat the disk, thereby closing the valve.

The valve shown in figure 4-10 is equipped with a test casting in the body of the valve. The bottom cover can be removed so you can check the valve for leakage.

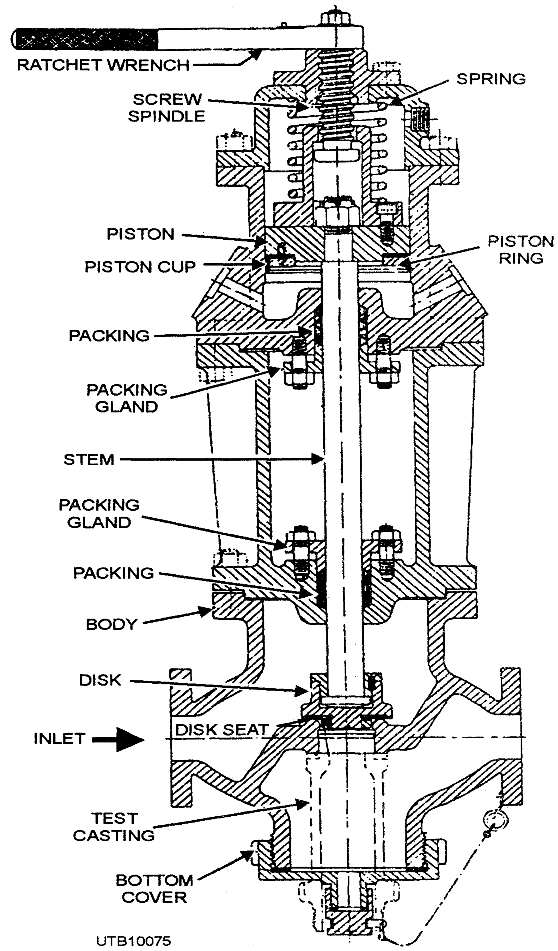


Figure 4-10.—Hydraulic control valve.

VALVE REPAIR

Periodic maintenance is the best way to extend the service life of valves and fittings. As soon as you see a leak, check to see what is causing it; then apply the proper remedy. This remedy may be as simple as tightening a packing gland nut. A leaking flange joint may need only to have the bolts tightened or to have a new gasket inserted. Dirt and scale, if allowed to collect, can cause leakage. Loose hangers permit sections of a line to sag. The weight of the pipe and the fluid in these sagging sections may strain joints to the point of leakage.

Whenever you intend to install a valve, make sure you know its function. In other words, is it supposed to prevent backflow, start flow, stop flow, regulate flow, or regulate pressure? Look for the information stamped on the valve body by the manufacturer: type of system (oil, water, gas); operating pressure; direction of flow; and other information.

You should also know the operating characteristics of the valve, the type of metal it is made of, and the type of end connection it has. Operating characteristics and material affect the length and type of service a valve can provide. End connections indicate whether or not a particular valve is suited for installation in the system.

Valves should be installed in accessible places and with enough headroom to allow for full operation. Install valves with stems pointing upward whenever possible. A stem position between straight up and horizontal is acceptable, but avoid the inverted position (stem pointing downward). When the valve is installed in the latter position, sediment collects in the bonnet and scores the stem. When a line is subject to freezing temperatures, liquid trapped in the valve bonnet may freeze and rupture it.

Globe valves may be installed with pressure either above or below the disk. It depends upon what method is best for the operation, protection, maintenance, and repair of the machinery. You should ask what would happen if the disk became detached from the stem? This is a major consideration in determining whether pressure should be above the disk or below it. Check the blueprints for the system to see which way the valve should be installed. Pressure on the wrong side of the disk can also cause serious damage.

Valves that have been in constant service over a long period of time eventually require gland tightening, replacing, or a complete overhaul. When a valve is not doing the job, it should be dismantled and all parts inspected. For proper operation, parts must be repaired or replaced.

Spotting-in Valves

Spotting-in is the method used to determine visually whether or not the seat and the disk make good contact with each other. To spot-in a valve seat, first apply a thin coating of prussian blue evenly over the entire machined face surface of the disk. Then insert the disk into the valve and rotate it a quarter turn, using light downward pressure. The prussian blue adheres to the valve seat at those points where the disk makes contact. Figure 4-11 shows what correct and imperfect seals look like when they are spotted-in.

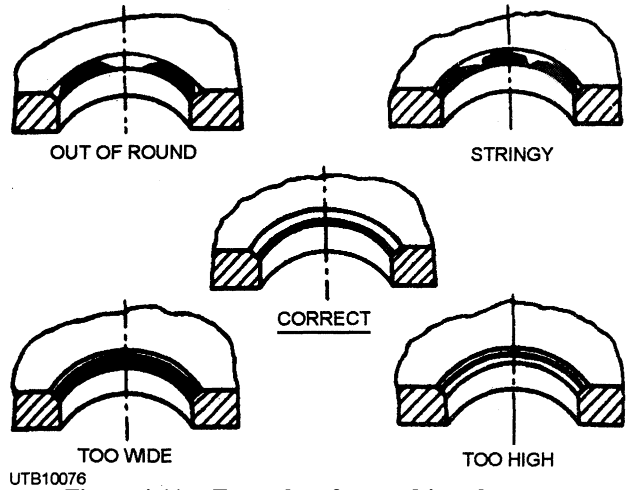


Figure 4-11.—Examples of spotted-in valve seats.

After you have examined the seat surface, wipe all the prussian blue off the disk face surface. Apply a thin, even coat of blue to the contact face of the seat. Again, place the disk on the seat and rotate the disk a quarter of a turn. Examine the blue ring that appears on the disk. It should be unbroken and of uniform width. If the blue ring is broken in any way, the disk does not fit properly.

Grinding-in Valves

Grinding-in is a manual process used to remove small irregularities by grinding together the contact surfaces of the seat and disk. Grinding-in should not be confused with refacing processes in which lathes, valve reseating machines, or power grinders are used to recondition the seating surfaces.

To grind-in a valve, first apply a small amount of grinding compound to the face of the disk. Then insert the disk into the valve and rotate the disk back and forth about a quarter of a turn. Shift the disk-seat relationship from time to time, so the disk is moved gradually, in increments, through several rotations. During the grinding-in process, the grinding compound is gradually displaced from between the seat and disk surfaces; therefore, it is necessary to stop every minute or so to replenish the compound. When you do this, wipe both the seat and the disk clean before applying the new compound to the disk face.

When it appears that the irregularities have been removed, check your work by spotting-in the disk to the seat in the manner described previously.

Grinding-in is also used to follow up all machine work on valve seats or disks. When the seat and disk are first spotted-in after they have been machined, the seat contact is very narrow and located close to the bore. The grinding-in, using finer and finer compounds as the work progresses, causes the seat contact to become broader. The contact area should be a perfect ring covering approximately one third of the seating surface.

Be careful that you do not overgrind a seat or disk. Overgrinding tends to produce a groove in the seating surface of the disk. It may also round off the straight, angular surface of the disk. Overgrinding must be corrected by machining.

Lapping Valves

When a valve seat contains irregularities that are too large to be removed by grinding-in, you can remove them by lapping. A cast-iron tool (LAP) of exactly the same size and shape as the disk is used to rule the seat surface. Two lapping tools are shown in figure 4-12.

Here are the most important points to remember while using the lapping tool.

1. Do not bear heavily on the handle of the lap.
2. Do not bear sideways on the handle of the lap.
3. Change the relationship between the lap and the seat, so the lap gradually and slowly rotates around the entire seat circle.
4. Keep a check on the working surface of the lap. If a groove develops, have the lap refaced.
5. Always use clean compound for lapping.
6. Replace the compound often.
7. Spread the compound evenly and lightly.
8. Do not lap more than is necessary to produce a smooth, even seat.

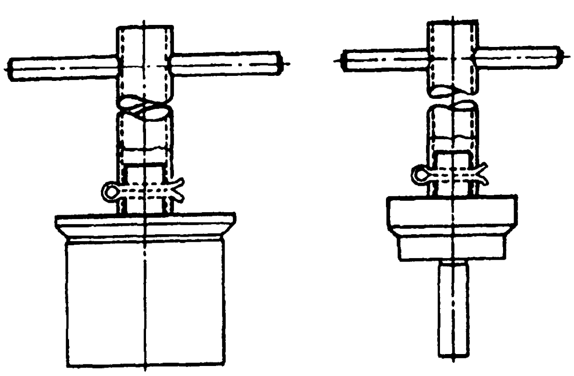


Figure 4-12.—Lapping tools.

9. Always use a fine grinding compound to finish the lapping job.
10. When you complete the lapping job, spot-in and grind-in the disk to the seat.

Use only approved abrasive compounds to recondition seats and disks. Compounds for lapping and grinding disks and seats are supplied in various grades. Use a coarse grade compound when there is extensive corrosion or deep cuts and scratches on the disks and seats. Use a compound of medium grade to follow up the coarse grade. It may also be used to start the reconditioning process on valves that are not severely damaged. Use a fine grade compound when the reconditioning process nears completion. Use a microscopic fine grade for finish lapping and for all grinding-in.

Refacing Valves

Badly scored valve seats must be refaced in a lathe with a power grinder or with a valve reseating machine. Use the lathe, rather than the reseating machine, to reface disks and hard-surfaced seats. Work that must be done on a lathe or with a power grinder should be turned over to machine shop personnel. This discussion applies only to refacing seats with a reseating machine.

To reface a seat with a reseating machine (fig. 4-13) attach the correct 45-degree facing cutter to a

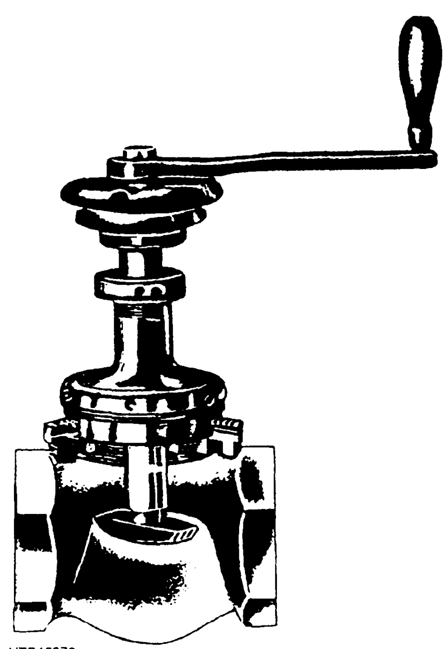


Figure 4-13.—Valve reseating machine.

reseating machine. With a fine file, remove all high spots on the surface of the flange upon which the chuck jaws must fit. Note that a valve reseating machine can be used ONLY with a valve in which the inside of the bonnet flange is bored true with the valve seat. If this condition does not exist, the valve must be reseated in a lathe and the inside flange bored true.

Before placing the chuck in the valve opening, open the jaws of the chuck wide enough to rest on the flange of the opening. Tighten the jaws lightly, so the chuck grips the sides of the valve opening securely. Tap the chuck down with a wooden mallet until the jaws rest on the flange firmly and squarely. Then tighten the jaws further.

Adjust and lock the machine spindle in the cutting position and begin cutting by turning the crank slowly. Feed the cutter slowly, so very light shavings are taken. After some experience, you can tell whether or not the tool is cutting evenly all around. Remove the chuck to see if enough metal has been removed.

Be sure the seat is perfect. Then remove the 45-degree cutter and face off the top part of the seat with a flat cutter. Dress the seat down to the proper dimensions as follows:

Width of Seat	Size of Valve
l/16 inch	l/4 to 1 inch
3/32 inch	1 l/4 to 2 inches
l/8 inch	2 l/2 to 4 inches
3/16 inch	4 l/2 to 6 inches

After the refacing, grind-in the seat and disk. Spot-in as necessary to check the work. A rough method of spotting-in is to place pencil marks at intervals of about l/2 inch on the bearing surface of the seat or disk. Then place the disk on the seat and rotate the disk about a quarter of a turn. If the pencil marks in the seating area rub off, the seating is satisfactory.

Repacking Valve Stuffing Boxes

When the stem of a globe valve is in good condition, stuffing box leaks can usually be stopped by setting up on the gland. If this does not stop the leakage, repack the stuffing box. The gland must not be set up or packed so tightly that the stem binds. If the leak persists, a bent or scored valve stem may be the cause of the trouble.

Coils (string) and rings are the common forms of packing used in valves. The form to be used in a particular valve is determined, in part, by the size of the packing requi red. In general, rings are used in valves that require packing larger than 1/4 inch. When a smaller size is required, string packing is used.

When you repack a valve stuffing box, place successive turns of the packing material around the valve stem. When string packing is used, coil it around the valve stem. Bevel off the ends to make a smooth seating for the bottom of the gland. Then put on the gland and set it up by tightening the bonnet nut or the gland bolts and nuts. To prevent the string packing from folding back when the gland is tightened, wind the packing in the direction in which the gland nut is to be turned. Usually, where successive rings are used, the gaps in the different rings should be staggered.

Gate, globe, angle, and stop-check valves are made to back seat the stem against the valve bonnet when the valve is fully opened. Back seating of these valves is a safety feature to eliminate the stem being forced out under pressure while the valve is fully opened. Back seating makes repacking of the stem stuffing box possible under pressure; however, you should attempt this only in emergencies and with extreme caution.

Q1. What structure of a valve distinguishes one type of valve from another?

Q2. Direction of flow is indicated on the exterior of a check valve in what manner?

Q3. Hydraulic control valves are used in what type of plumbing system?

Q4. To reface valves, you can use the valve reseating machine only when what condition exists?

VALVE ACCESSORIES

LEARNING OBJECTIVE: *Recognize the different types of valve accessories and the methods used to maintain them.*

Accessories that aid in the control of valves include valve boxes, floor stands, and post indicators. Each of these supporting materials is discussed briefly below.

Street valves must be accessible for turning them off and on; and, with large valves, the entire valve should be accessible for servicing. Since valves are placed at various depths, valve boxes are made in two or more pieces and telescope to provide adjustable lengths.

Valve controls may be mounted on floor stands for operating valves below a floor. They are operated manually by turning the handwheel or by automatic controls. Some floor stands are equipped with indicators to show when the valves are open or closed. Floor stands (fig. 4-14) are essentially an extension of the valve stem.

Post indicators (fig. 4-15) provide for operating nonrising-stem gate valves that are below the ground or floor level. They are used principally in fire-flow systems, and in this function must be fully approved by the Underwriters Laboratories and the Associated Factory Manual Fire Insurance Companies (indicated on the post by the letters UA and FM). The indicator post is operated by an attached vise when not in use. The valve is opened by turning the wrench to the left, unless otherwise indicated. The OPEN or CLOSED position of the valve is clearly indicated by the target places which show the words *Open* and *Shut* in glass protected openings on both sides of the post. Most post indicators are sealed open for safety. If the seal has been broken, the operator should report this condition to higher authority immediately.

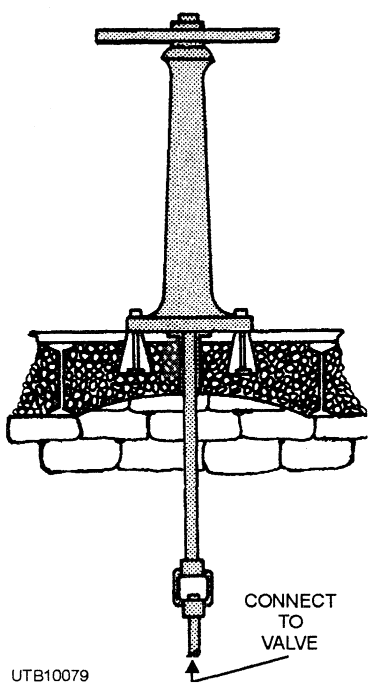


Figure 4-14.—Floor stand.

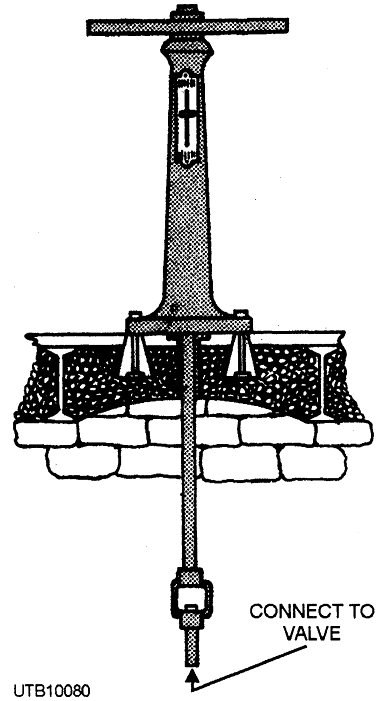


Figure 4-15.—Floor stand with post indicator.

GEARBOXES

Most large manually operated valves are operated through gears as are motor-operated valves. These gears are housed in gearboxes.

Monthly or quarterly, lubricate the gearing under the manufacturer's instructions.

Semiannually, check gear operation through a complete cycle of opening and closing. Listen for undue noise and observe smoothness of operation of the valve opening, and check for lubricant leakage from the flanges. Upon finding any evidence of improper operation, the operator should open the gearbox, inspect the gears, and make necessary repairs.

Annually, inspect the housing for corrosion; clean and paint it as necessary.

VALVE BOXES

All buried valves must have means for the valve key to reach the operating nut. This unit consists of a cast-iron pipe about 6 inches in diameter with a special yoke at the bottom to rest on the valve bonnet and a cover at the street level (or ground level, if not in the street). These valve boxes are adjustable in height; some have covers with locknuts to prevent unauthorized access.

Maintenance of valve boxes should be done twice a year like the valve maintenance schedule for operation.

Maintenance consists of cleaning out debris in the box, checking for corrosion, checking the elevation of the top, and checking alignment of the box, so the valve key can be inserted readily. When the valve box has corroded and is no longer serviceable, remove it and replace it with a new unit. When changes in street or ground level have left the valve box too high or too low, adjust the height so the cover is at street or ground level.

VALVE POSITION INDICATORS

Different types of valves have different types of valve position indicators. Nonrising-stem gate valves may have indicators on the floor stand. Filter plant valves may have indicators on the filter operating table; and butterfly valves, or other valves, used for flow control or throttling, may have indicator units that are controlled electrically and look like an ammeter. The care required depends on the design of the indicator unit; for example, post indicators require lubrication quarterly and, position indicators, that are controlled electrically, should be checked for contact, wiring, and so on, yearly.

Q5. Floor stands with post indicators are used for operating what type of valve in what condition?

Q6. A cast-iron pipe, approximately 6 inches in diameter, has a yoke at the bottom to rest on the valve bonnet and a cover at street level. This is what type of valve accessory?

WATER METERS

LEARNING OBJECTIVE: *Identify types of water meters and methods of obtaining readings.*

Water meters measure the flow of water within a line to a point of distribution, such as laundries, housing areas, and so on. There are various types of water meters. One type is the disk type of volume meter. This water meter is used chiefly for services supplied through pipes less than 1 1/2 inches in diameter, although water meters are made in sizes up to 6 inches.

Figure 4-16 shows the nutating disk volume meter. This type of meter is mainly used for individual service

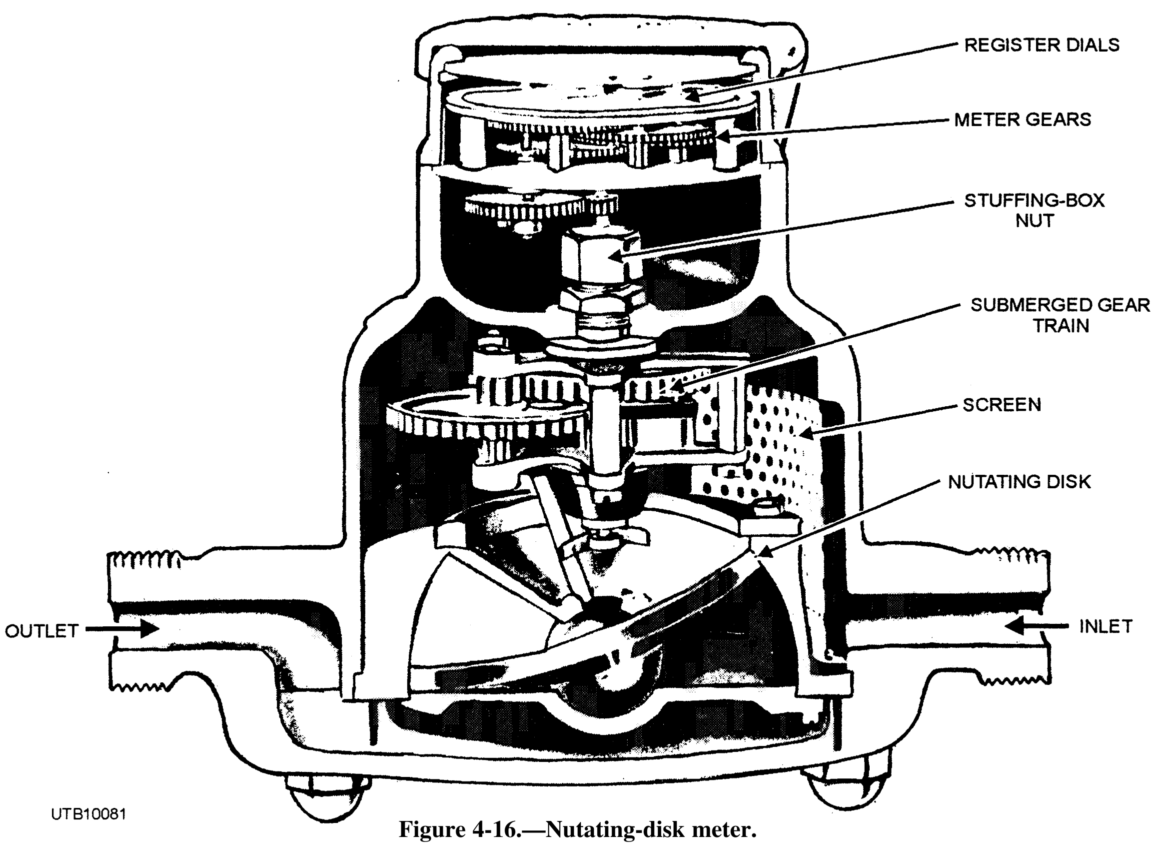


Figure 4-16.—Nutating-disk meter.

connections, as it is accurate for very low flow. A flow above normal causes rapid wear. The disk type of meter contains a measuring chamber of definite content in which a disk is actuated by the passage of water. Each cycle of motion of the disk marks the discharge of the contents of the measuring chamber. By means of gearing, the motion of the disk is translated into units of water volume on the register dial.

When installing a water meter, make sure it is horizontal and that it operates under back pressure. The meter should be located near the pressure-reducing valve at underground level; so in freezing temperatures, ensure the meter is protected from exposure.

Water is measured in terms of rate-of-flow (volume passing in a unit of time) or total volume. Units and equivalents usually are as follows:

Unit	Equivalent
Cubic feet per second (cfs)	6448.83 gpm
cfs	46,315 gallons per day (gpd)
gpm	1,440 gpd
Million gallons per day (mgd)	1.547 cfs
mgd	694.4 gpm
cu ft	7.48 gal

NOTE: IN READING A METER, YOU SHOULD FIRST DETERMINE WHETHER IT IS MEASURING THE WATER FLOW IN CUBIC FEET OR IN GALLONS.

METER DIALS

Two general types of meter dials are used: the straight-reading type and the circular-reading type. Each type is discussed in the following paragraphs.

The STRAIGHT-READING DIAL shown in figure 4-17 may be read in the same way as mileage on an automobile. When the meter register has one or more fixed zeros, always be sure to read them in addition to the other numerals.

In the CIRCULAR-READING DIAL, when the hand on a scale is between two numbers, the lower number is read. If the hand seems exactly on the number, check the hand on the next lower scale. If that hand is on the "1" side of zero, read the number on which the hand lies; otherwise, read the next lower number. The procedure for reading the circular-reading dial, shown in gallons in figure 4-18, is to begin with the "1,000,000" circle and read clockwise to the "10" circle, the scales registering 9, 6, 8, 7, 2, and 1; respectively, making a total of 968,721 gallons.

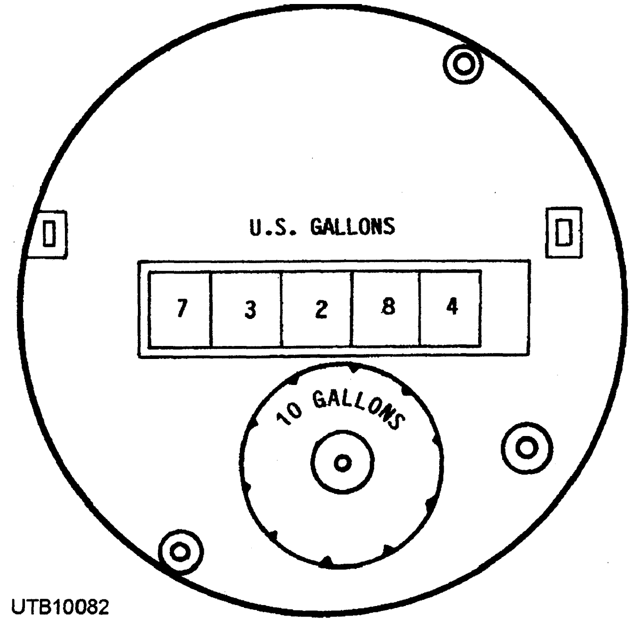


Figure 4-17.—Straight-reading meter dial.

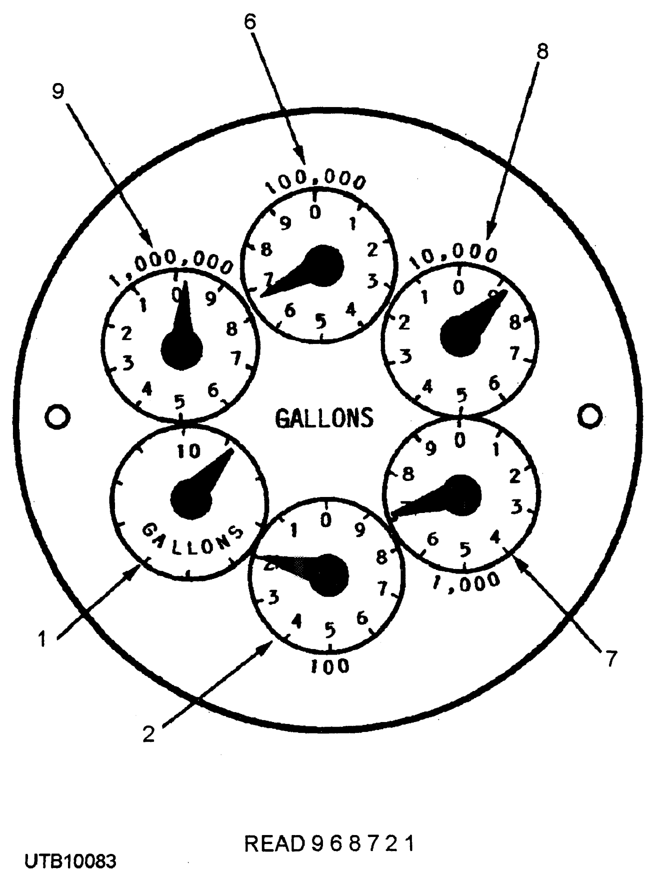


Figure 4-18.—Reading the circular-reading meter dial in gallons.

OBTAINING CURRENT READING

Since the registers are never reset while the meters are in service, the amounts recorded for any period of time must be determined by subtraction. To obtain a current reading, subtract the last recorded reading from the current. dial reading. Remember, the maximum amount that can be indicated on the usual line meter before it turns to zeros and begins all over again is 99,999 cubic feet, or 999,999 gallons. Thus, to obtain a current measurement when the reading is lower than the last previous one, add 100,000 to the present reading on a cubic foot meter, or 1,000,000 to the present reading on a gallon meter. The small denomination scale, giving fractions of one cubic foot or ten gallons, is disregarded in the regular reading. It is used for testing only.

Q7. What is the purpose of a water meter?

Q8. What should you determine about flow in a water meter before reading it?

Q9. For a circular meter, you should read the meter in what direction?

FIRE HYDRANTS

LEARNING OBJECTIVE: *Recognize types of fire hydrants and methods for inspection, flushing, and testing.*

The fire department (or safety office) is responsible for the selection and use of fire-fighting equipment, including fire hydrants. It is the responsibility of a Utilitiesman to ensure that water is available to the hydrant and that control valves operate properly.

MAINTENANCE

Most fire hydrants consist of a cast-iron barrel with a bell or flange fitting at the bottom to connect it to a branch from the main; a valve, of the gate or compression type, has a long stem terminating in a nut above the barrel and one or more outlets. There are many designs of fire hydrants, two of which are the DRY-BARREL HYDRANT and the WET-BARREL HYDRANT.

In cold climates, where freezing occurs, dry-barrel hydrants are used (fig. 4-19). With this type of hydrant, the drain valve or weep hole must be kept open in systems where the groundwater level is below the hydrant foot, so the barrel can drain and not freeze in cold weather. A box placed over a hydrant affords some protection against freezing and leaves the top of the hydrant free of snow and ice. The hydrant is equipped with two 2 1/2-inch hose outlets and a 4 l/2-inch pumper outlet whose threads conform exactly to the standards specified in *Screw Threads and Gaskets for Fire Hose Connections,* NFPA, 1963.

Where freezing temperatures do not occur, use wet-barrel (or California) hydrants (fig. 4-20). With this type of hydrant, all the packing glands must be kept in good condition to prevent leakage as well as to allow free operation of the stem controlling each outlet. Valve seats for wet-barrel hydrants afford easy access for inspection.

Hydrants exposed to traffic hazards must be protected by appropriate guards. Most damage is caused by an accident or by improper or careless operation.

Much of this can be prevented when operating personnel are made to realize that a properly functioning fire hydrant is critical to the protection of life and property at the activity. Without much extra labor or effort, operating personnel can take several precautions to keep the hydrant structure in good condition. General precautions are listed below.

1. The operation of fire hydrants should be restricted to personnel trained in this and allied work, such as fire fighters, utility maintenance, and operating personnel ONLY.

2. For opening and closing the hydrant, use ONLY an approved hydrant wrench. The reason is that ordinary wrenches can ruin the operating nut.

3. Keep the hydrant drained when it is not in use. This is particularly important in cold climates where ice in the hydrant may make it inoperative.

4. Pipes should be connected only to draw off water for fire-fighting purposes except in an emergency. Any such connection must be removed immediately after an emergency. Connections made to provide a temporary supply for vehicle washing, irrigation, and so on, is not permitted.

5. The hydrant valve should be kept in either the wide **OPEN** or fully **CLOSED** position and never used to throttle the flow of water. When it is necessary to restrict the flow, separate globe valves should be attached to the hydrant discharge outlet.

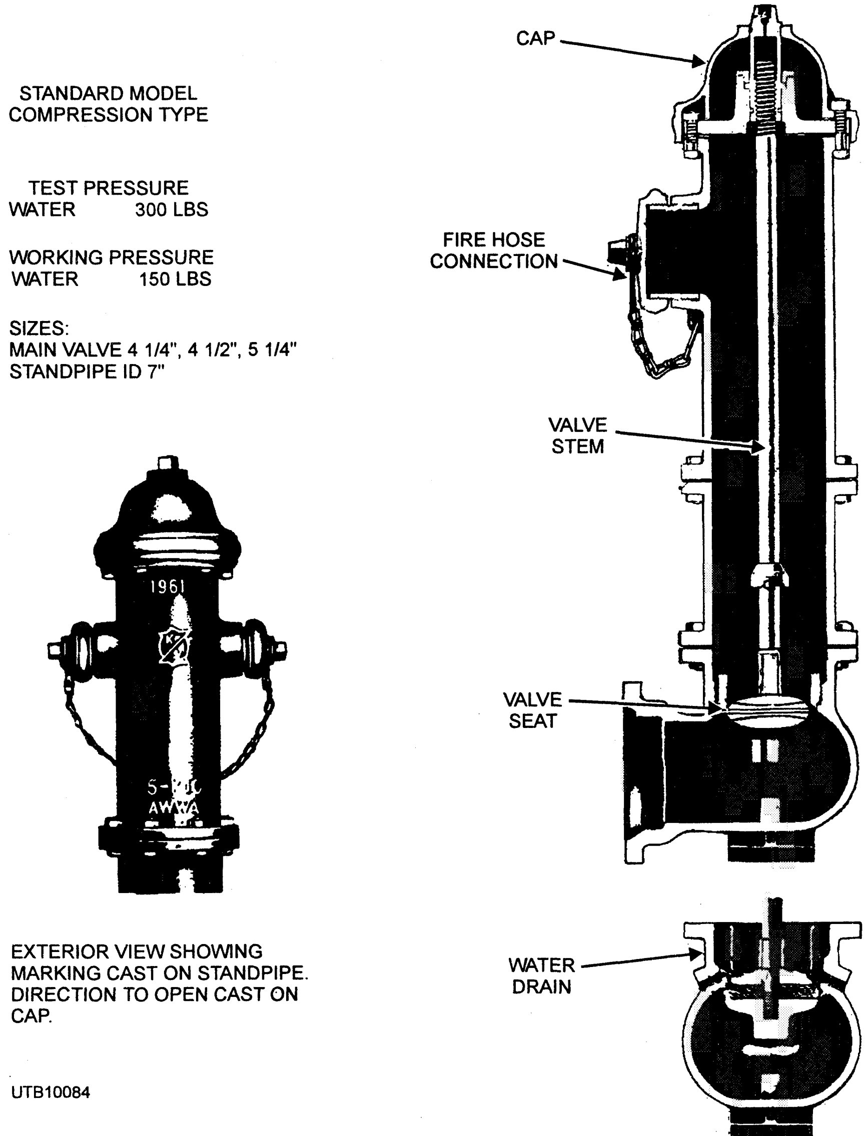


Figure 4-19.—Dry-barrel fire hydrant.

Figure 4-21 shows the proper method of installing and supporting fire hydrants.

FLUSHING AND TESTING

Of course, newly installed pipe must be tested for leaks by means of air or water. To make an AIR TEST, plug up all openings in the system, connect a source of compressed air to the system, and bring the pressure up slowly to the designed working pressure. Use a soapy water solution and cover each joint, then check for leaks. When a leak is present, you can detect the location by bubbles forming around the joint from the escaping air. When a leak is discovered, mark each spot with chalk or soapstone. DO NOT, AT THIS TIME, ATTEMPT TO REPAIR THE LEAK. After the line has been tested completely, relieve the pressure from within and repair the joint. Repeat the testing and repairing procedures until all the leaks have been located and repaired.

The procedure for making a WATER TEST is similar to that used for an air test. Water is used instead of air, and you do not use a soapy water solution to cover the joints. The pipe is filled with potable water, and pressure is applied and maintained by means of a hand pump. See that no air has been retained in the pipe being tested. Let it stand under operating pressure from 4 to 8 hours and inspect for leaks and maintenance of pressure during this period.

Q10. What department is responsible for selection of fire hydrants to be used in a system?

Q11. What are the two types of fire hydrants?

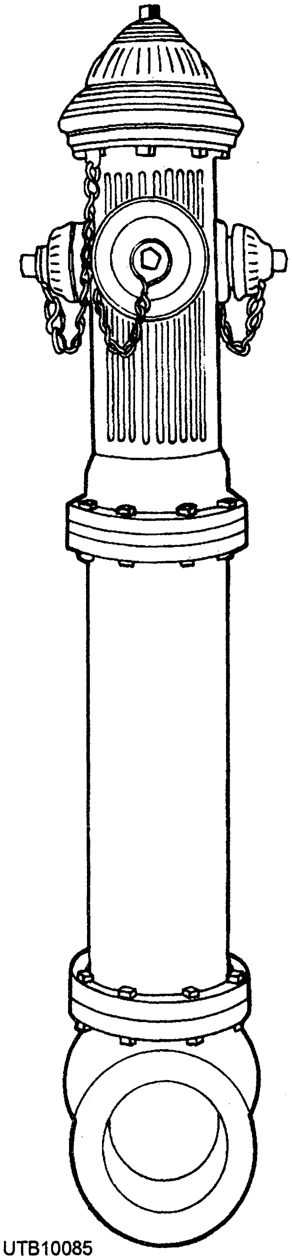


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Figure 4-20.—Wet-barrel, or California, fire hydrant.

DISINFECTION OF WATER-SUPPLY SYSTEM COMPONENTS

LEARNING OBJECTIVE: *Understand disinfection chemicals, methods, and emergencies and their applications. Understand the application of pipe supports and insulation in water-supply systems.*

Water mains, wells, filters, storage tanks, and other components of a water-supply system become contaminated during installation and repair. Flushing the system to remove dirt, waste, and surface water is the first step in disinfecting the water system, but it is not a sufficient safeguard. To ensure a safe water supply, you must thoroughly disinfect each unit of the system before it is placed in operation. The chemicals used in disinfecting a water-supply system are the same as those used in disinfecting water; for example, a hypochlorite solution or chlorine gas.

DOSAGE REQUIRED

The chlorine dosage required to disinfect a unit depends upon the contact time and the amount of jute, untarred hemp, and organic chlorine-consuming material present. Under average conditions, the following minimum dosages are recommended:

Unit	**Minimum dosage** (ppm)
Pipe	50
Storage tank	50
Filter	100
Well	150

The volume of water in the unit to be disinfected must be computed before the chlorine dosage can be estimated. Use the formula for finding the volume of a tank ($V = r^2h$) and divide the volume by 231 to determine the number of gallons (231 cubic inches = 1 gallon). The volume of water in different sizes of pipe is listed below.

Pipe diameter (inches)	**Volume per foot of pipe (gallons)**
6	61.47
8	82.61
10	104.08
12	125.88
16	1610.45
20	2016.32

APPLYING DISINFECTANT

The following methods of applying disinfectants should be observed:

- Liquid chlorine is applied by portable gas chlorinators. Chlorine cylinders should not be connected directly to mains because water may enter the cylinder and cause severe corrosion and hazardous leakage.

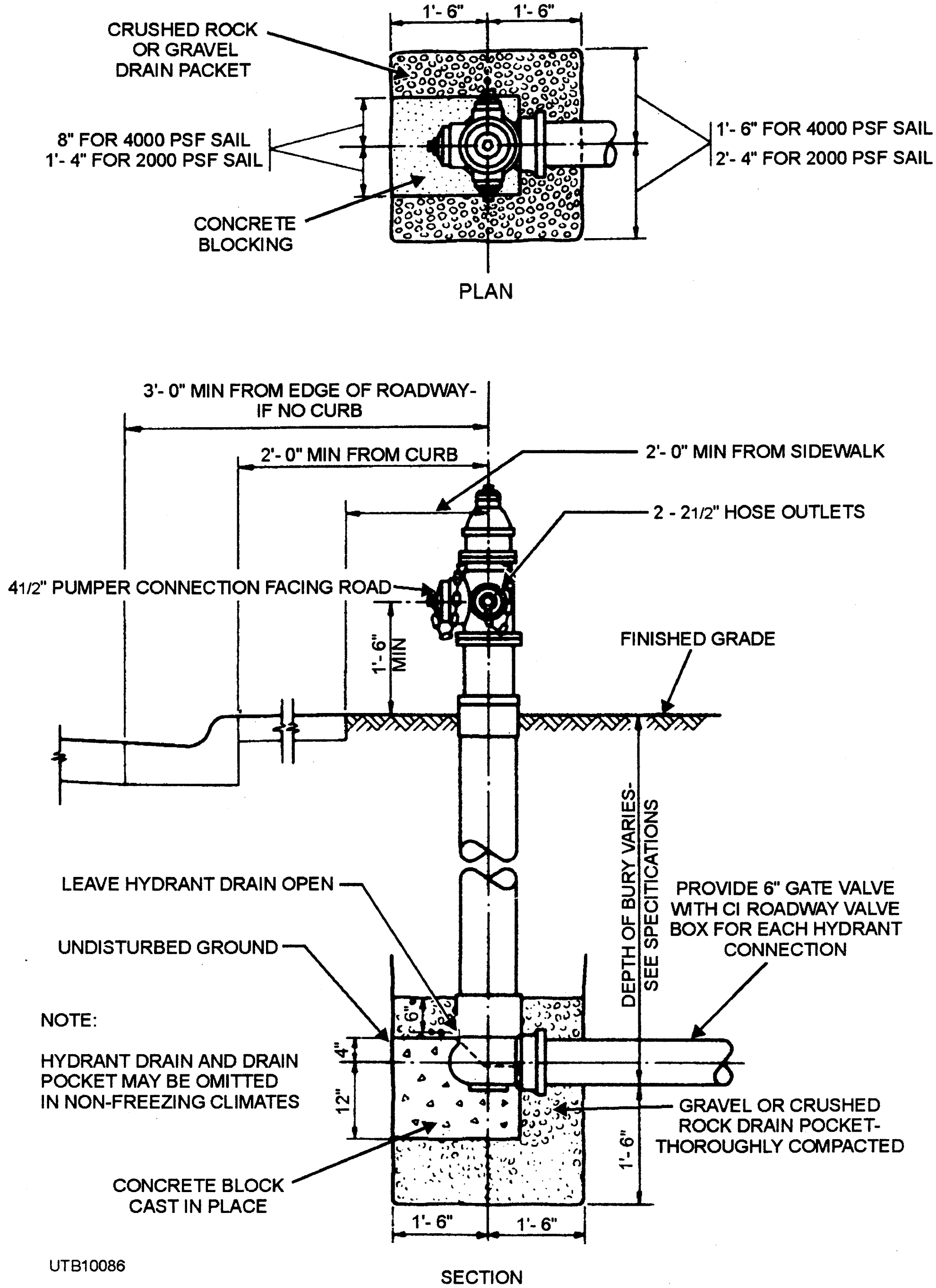


Figure 4-21.—Fire hydrant installation.

- Hypochlorite solution is usually applied by measuring pumps, gravity-feed mechanisms, or portable pipe disinfecting units.

When applying disinfectants, use the following procedures:

- Before adding disinfectant, flush the section thoroughly with water until dirt and mud are removed. A velocity of at least 3 feet per second is required for adequate scouring.

- Stop all branches and other openings with plugs or heads properly braced to prevent blowouts.

- Disinfect the water mains in sections and feed the disinfecting agent through a tap or hydrant at the end of each section. When a portable gas chlorinator or hypochlorinator is available, feed the discharge from the chlorinator into an auxiliary waterline leading to one of the hydrants or taps.

Bleed the air from the line at high points and crowns. Add the predetermined chlorine dosage as the main is filled slowly with water. Continue feeding until the water discharged at the other end of the section contains the desired residual chlorine. Let the chlorinated water remain in the contaminated unit or section for 24 to 48 hours. Then flush until the chlorine residual is only that amount normally in the supply. Make daily bacteriological analyses of water samples until the analyses show no further disinfection is required.

When a chlorinator is not available, feed a strong hypochlorite solution into the main from a pail through the highest hydrant top or valve with the bonnet removed. Add the hypochlorite and water until the main is full and the chlorine residual is about 50 ppm. Test the residual at the far end of the main. Bleed out air trapped in the line.

When the mains are to be disinfected under pressure by using supply or booster pumps, feed the chlorine into the main with chlorinators or hypochlorite feeders. Take care to ensure adequate and accurate distribution of the disinfecting agent when pumps are being used.

The use of dry calcium hypochlorite directly in mains is not uniformly effective because of unequal mixing with the water; therefore, when calcium hypochlorite is used, prepare a solution of this chemical beforehand.

EMERGENCIES

Natural contamination of water supplies can increase because of emergencies. Standby or portable chlorinators must be working to meet emergency disinfection requirements in water-supply components. This equipment should not be used to make drinking water safe after bombing, sabotage, or biological warfare has made water sources untreatable with chlorine for disinfection.

PIPE SUPPORTS

Where pipes are exposed aboveground and in the interior of buildings supplying air, water, or steam, they must be supported adequately to prevent sagging. This is because the weight of the pipes, plus the fluid in them, can cause breaks, strain joints, and cause leaks in valves.

The main supply pipe (vertical or horizontal) must be adequately supported to take its weight off the fitting and to prevent future leaks. Refer to figure 4-22 for some methods of supporting cast-iron soil pipe and

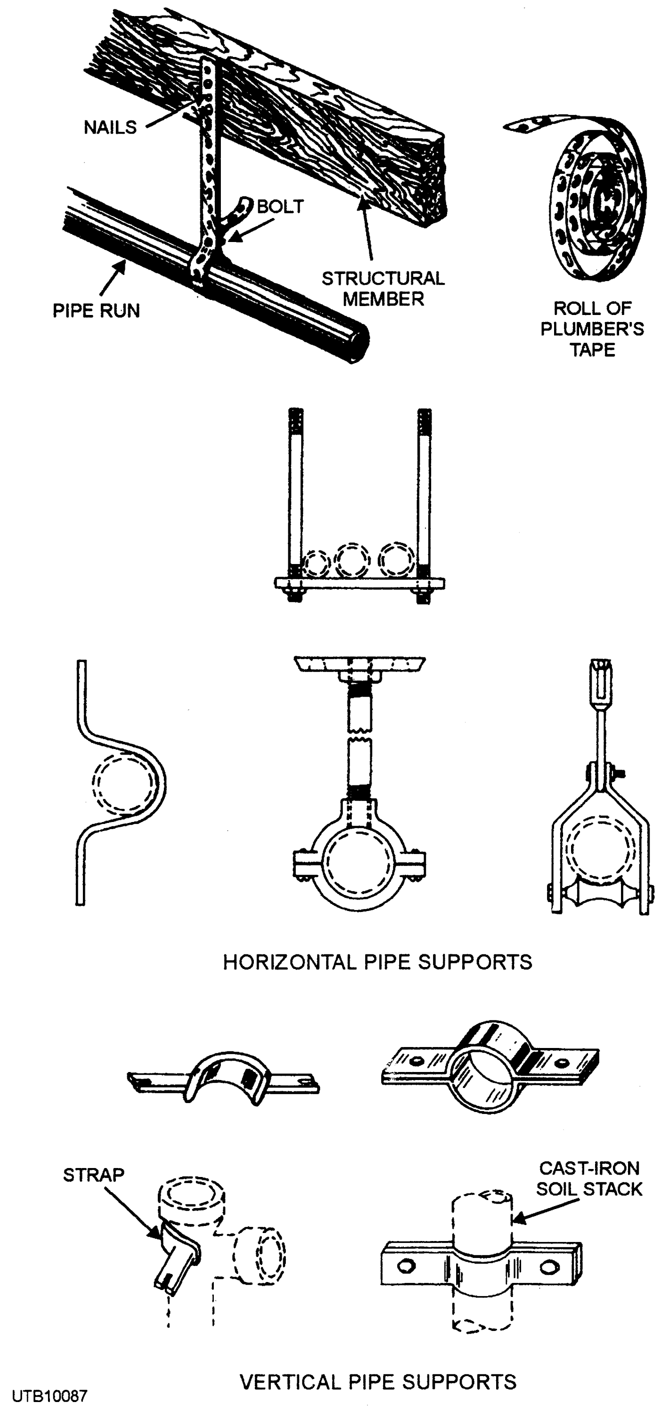


Figure 4-22.—Methods of supporting pipes.

galvanized pipe. Fixture supply risers are pipes taken off of the supply pipes to furnish air, water, or steam to the fixtures being installed. These risers may be in the wall or exposed. They must be made tight and tested before being closed up in a wall. All vertical fixture risers should be supported at each floor level or in a change of direction. They should never be supported by the horizontal fixture supply branches.

As shown in figure 4-23, thrust blocks should be installed on water mains at all changes of direction to prevent pipe from separating from water pressure. Consult the chart at the bottom of the figure for dimensions of the thrust block according to the pipe size and compaction rating of the soil.

INSULATION

The primary purpose of insulation is to prevent heat passage from steam or hot-water pipelines to the surrounding air or from the surrounding air to cold-water pipes. Thus hot-water lines are insulated to prevent loss of heat from the hot water, while drinking waterlines are insulated to prevent absorption of heat in drinking water.

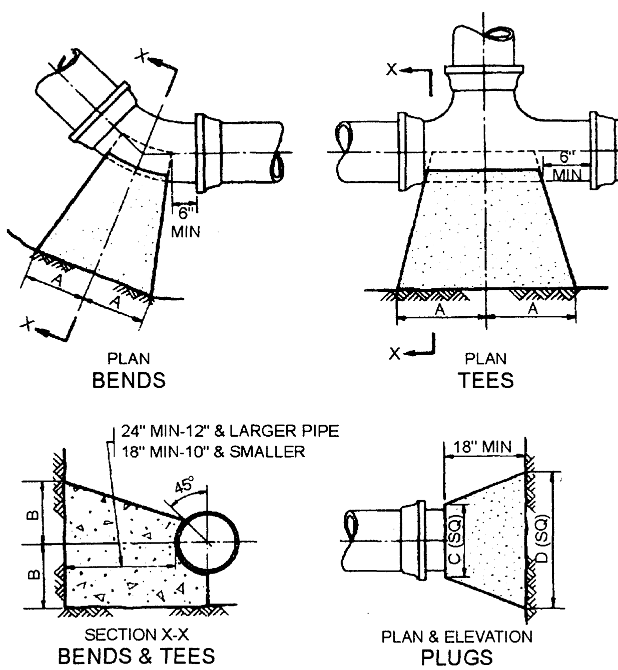
Insulation keeps moisture from condensing on the outside of cold pipes. An example of condensation consists of droplets of moisture on the outside of a glass of ice water on a warm day. The same thing happens to the outside of a pipe containing cold water when the outside of the pipe is exposed to warm air. Insulation also prevents water from freezing in a pipe, especially when the pipe runs outside a building or in a building without heat.

Insulation is used on heating and air-conditioning ducts. The two kinds of duct insulation are (1) inside and (2) outside. The outside insulation is for the protection of heat loss, whereas the inside insulation is used for protection against noise and vibration from heating or air-conditioning equipment.

Insulation subdues noise made by the flow of water inside pipes, such as water closet discharges. Bathrooms directly above living rooms should be insulated. Insulation is vital in high buildings where water falls a long way, especially when the water falls in soil stacks and headers. Insulation also protects refrigerated and chilled waterlines that cool electrical and motor-driven equipment.

Insulation is made in two forms: (1) rigid preformed sections and (2) blankets. Rigid preformed sections are used on pipe runs and to protect other objects which they are designed to fit. Blanket-type insulation, manufactured in strips, sheets, and blocks, is wrapped around objects that are irregular in shape and large, flat areas. Blanket-type insulation protects against heat loss and fire. This type of insulation is used on boilers, furnaces, tanks, drums, driers, ovens, flanges, and valves. It comes in wool-felt and hair-felt rolls, aluminum foil rolls, and in an irregular preformed covering.

Blanket insulation comes in different widths and thicknesses, depending upon the type of equipment to be insulated. It resists vermin, rodents, and acid. It is also fireproof.



TYPE	SIZE	1/4 BENDS A	1/4 BENDS B	1/8 BENDS A	1/8 BENDS B	1/16 BENDS A	1/16 BENDS B	TEES A	TEES B	PLUGS C	PLUGS D
TYPE I 4000 PSF SOIL	6"	8"	10"	6"	8"	3"	8"	8"	8"	10"	15"
	8"	12"	12"	8"	10"	5"	9"	9"	12"	12"	20"
	10"	16"	14"	10"	12"	6"	10"	11"	14"	14"	25"
	12"	19"	16"	12"	14"	8"	11"	14"	16"	16"	30"
	14"	23"	18"	14"	16"	10"	12"	16"	18"	18"	34"
	16"	26"	20"	16"	18"	11"	13"	18"	20"	20"	38"
TYPE II 2000 PSF SOIL	6"	16"	10"	9"	10"	6"	8"	10"	12"	10"	21"
	8"	22"	13"	12"	13"	8"	10"	13"	16"	12"	29"
	10"	26"	17"	14"	17"	10"	13"	16"	20"	14"	36"
	12"	29"	21"	16"	21"	11"	16"	18"	24"	16"	41"
	14"	35"	24"	19"	24"	12"	20"	22"	27"	18"	48"
	16"	38"	27"	21"	27"	12"	24"	24"	30"	20"	54"

NOTE: BASE IN 100 PSI STATIC PRESSURE PLUS A.W.W.A. WATER HAMMER
ALL BEARING SURFACES TO BE CARRIED TO UNDISTURBED GROUND

STANDARD THRUST BLOCKS
FOR WATER MAINS

UTB10088

Figure 4-23.—Thrust block pipe supports.

Piping

Some of the insulating materials on the market today for insulating pipe are sponge felt paper, cork pipe covering, wool felt, flex rubber, fiber glass, magnesia, and types called antisweat and frostproof.

Sponge felt paper is composed of asbestos paper with a maximum amount of sponge evenly distributed within it, as shown in view A, figure 4-24. Sponge felt paper is manufactured to fit most pipe sizes. It comes in 3-foot lengths and from 1 to 3 inches in thickness.

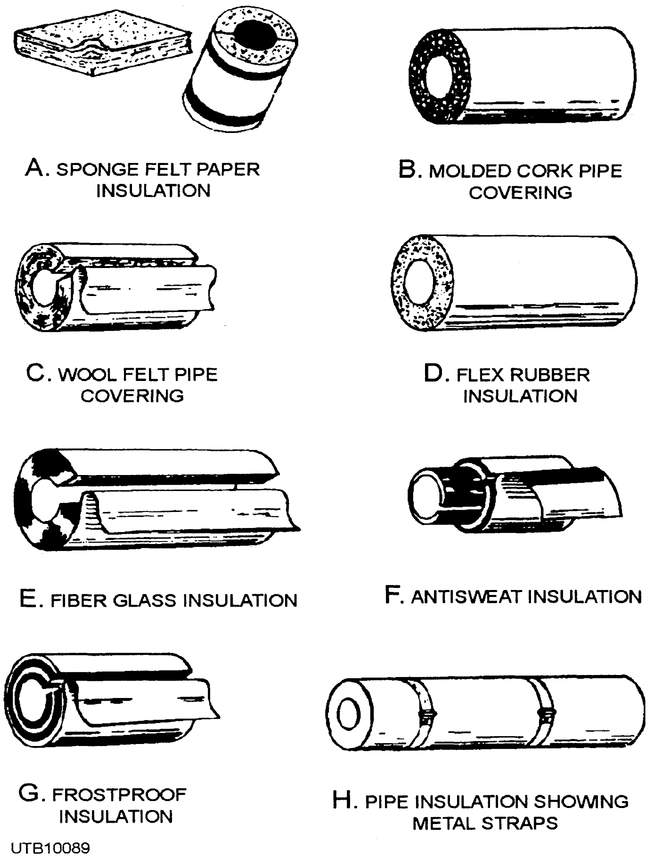


Figure 4-24.—Types of pipe insulation.

Sponge felt paper can be purchased in blocks of straight and preformed shapes for valves and fittings.

Cork pipe covering is a granulated material processed from the bark of cork trees. Granulated cork is compressed and molded to size and shape and finished with a coating of plastic asphalt. Cork pipe covering, as shown in view B, figure 4-24, is an ideal covering for brine, ammonia, ice water, and all kinds of cold waterlines, and it insulates well over a wide low-temperature range. Cork pipe covering does not rot or support combustion. Clean, sanitary, and odor free, it is available in a wide variety of sizes and shapes to fit various sizes of pipes and fittings.

Wool felt is made of matted fibers of wool, wool and fur, or hair, worked into a compacted material by pressure rolling. It is used on cold-water service and hot-water return lines. Wool felt preformed pipe covering is manufactured in thicknesses of l/2 to 1 inch, with a canvas jacket, as shown in view C, figure 4-24. It is manufactured in 3-foot lengths for straight runs of pipe.

Flex rubber insulation, shown in view D, figure 4-24, is a tough, flexible rubber material constructed of millions of uniform closed cells. It has good-insulating qualities, good-cementing qualities, excellent weather-aging qualities, and it is ideal for the prevention of sweating cold-water lines. In addition, it is water and flame resistant. Flex rubber insulation is recommended for covering tubing used in refrigeration and cold-water lines in homes, as well as in industrial plants and commercial buildings. This rubber insulating material comes in random lengths, with a wall thickness size of 3/8 to 3/4 inch. It is made to fit pipe sizes up to 4 inches.

Flex rubber insulation can be installed on pipes and tubing by slipping the insulation over the pipe when it is being assembled or by slitting the rubber lengthwise and sealing it with cement. Before installing flex rubber insulation on iron or galvanized pipes, paint the pipes with an asphaltic base primer to prevent corrosion caused by condensation.

Fiber glass pipe insulation, shown in view E, figure 4-24, is composed of very fine glass fibers, bound and formed together by an inactive resin type of mixture. It is formed into a flexible hollow cylinder and slit along its length for applying to pipes or tubing. It is furnished in 3-foot lengths with or without jackets. The insulation comes in thicknesses from l/2 to 2 inches and fits pipes from l/2 to 30 inches. Fiber glass insulation has a long life; it will not shrink, swell, rot, or burn. It is easily applied, light in weight, saves space, and has excellent insulating qualities.

Antisweat insulation, shown in view F, figure 4-24, is designed for cold-water pipes. It keeps the water colder in the pipes than most types of insulation; and when installed properly, it prevents condensation, or sweating, of the pipes.

The outstanding feature of antisweat insulation is its construction. It is composed of an inner layer of asphalt-saturated asbestos paper, a 1/2-inch layer of wool felt, two layers of asphalt-saturated asbestos felt, another l/2-inch layer of pure wool felt, and an outer layer of deadening felts with asphalt-saturated felts. The outer layer has a flap about 3 inches long that extends beyond the joint to help make a perfect seal. A canvas jacket is placed around each 3-foot length to protect the outer felt covering.

Frostproof insulation, shown in view G, figure 4-24, is manufactured for use on (1) cold-water service lines that pass through unheated areas and (2) those lines exposed to outside weather conditions.

Frostproof insulation is generally constructed of five layers of felt. There are three layers of pure wool felt and two layers of asphalt-saturated asbestos felt. Frostproof insulation is 1 1/4 inches thick and comes in 3-foot lengths with a canvas cover.

The pipe coverings shown in this section are some of the types of coverings that are installed easily, primarily because each section is split in half and has a canvas cover with a flap for quick sealing. Joint collars are furnished to cover joint seams on insulation exposed to outside conditions.

Cheesecloth is used on some types of insulation instead of canvas. To install the cheesecloth, use a paste to hold it in place. Allow enough cheesecloth to extend over the end of each 3-foot section to cover the joints.

After you have applied the cheesecloth and smoothed it out, install metal straps to hold the insulation firmly in place, as shown in view H, figure 4-24.

Valves and Fittings

Cover with wool felt, magnesia cement, or mineral wool cement of the same thickness as the pipe covering. These materials are molded into shape to conform with the rest of the insulation. When magnesia or mineral wool cement insulation is used, cover the insulation with cheesecloth to help bind and hold it in place.

Boilers and Storage Tanks

If the boilers and storage tanks are unjacketed, cover them with an approved insulation. Use only insulation approved by the MIL-STD. Some of the approved types of insulation for boilers and tanks are magnesia, mineral wool, calcium silicate, cellular glass, or other approved mineral insulation at least 2 inches thick. Insulation may be of either the block or the blanket type and must be wired securely in place in an approved manner. When applying insulation to the outside of a boiler or storage tank, put it over 1 1/2-inch wire mesh. The mesh is held away from the metal surface by metal spacers that provide an air space of at least 1 inch. When you use blanket or block material, fill the joints in the insulation with magnesia, mineral wool, or other suitable cement. Cover the surface of the insulation with a thin layer of hard-finished cement, troweled smooth, and reinforced with 1 1/2-inch wire mesh.

Q12. What minimum dosage of chlorine is required to disinfect a well under normal conditions?

Q13. An 8-inch pipe contains how many gallons of water per foot of pipe?

Q14. What velocity of water through a pipe is required for proper scouring action?

Q15. What is the purpose of a thrust block?

SHORING AND SCAFFOLDING

LEARNING OBJECTIVE: *Recognize safety and construction requirements of shoring and scaffolding.*

As a Utilitiesman, it is part of your job to see whether there is a need for shoring or scaffolding on the job. Most of the time, job problems and accidents are a direct result of inadequate planning. As you plan each job, ensure that you have provided the equipment necessary to do the job safely. In this section, safety and health requirements are addressed. For more information, *see* the *Safety and Health Requirements Manual,* EM 385-1-1, U.S. Army Corps of Engineers.

SHORING

The need to protect personnel who work in trenches is important. Following the ground investigation, you should make a decision as to how the sides of the trenches are to be protected. All necessary materials must be obtained and delivered to the site (figs. 4-25 through 4-28 and table 4-1). All trenches deeper than 5 feet must have their sides supported or protected by sloping or battering. Trenches can sometimes be made in the case of hard rock, when it becomes clear to experienced engineers on the site (as the trench proceeds) that the rock is solid and has no dangerous cleavage planes that could cause the side of the trench to collapse. The requirements are listed below.

1. Banks more than 5 feet high should be shored, laid back to a stable slope, or provided with other equivalent protection whenever workers must move around or are exposed to a cave-in. Trenches less than 5 feet in depth must be protected when examination of the ground indicates that hazardous ground movement may be expected. The safe angle of repose for soil conditions and bracing systems should be determined by a qualified person.

Table 4-1.—Trench Shoring-Minimum Requirements

Depth of trench	Kind of condition of earth	Size and spacing of members: Uprights — Minimum dimension	Uprights — Maximum spacing	Stringers — Minimum dimension	Stringers — Maximum spacing	Cross braces — Width of trench: Up to 3 feet	3 to 6 feet	6 to 9 feet	9 to 12 feet	12 to 15 feet	Cross braces — Maximum spacing: Vertical	Horizontal
Feet		Inches	Feet	Inches	Feet	Inches	Inches	Inches	Inches	Inches	Feet	Feet
5 to 10	Hard, compact	3 × 4 or 2 × 6	6			2 × 6	4 × 4	4 × 6	6 × 6	6 × 8	4	6
	Likely to crack	3 × 4 or 2 × 6	3	4 × 6	4	2 × 6	4 × 4	4 × 6	6 × 6	6 × 8	4	6
	Soft, sandy, filled........	3 × 4 or 2 × 6	Close sheeting	4 × 6	4	4 × 4	4 × 6	6 × 6	6 × 8	8 × 8	4	6
	Hydrostatic pressure......	3 × 4 or 2 × 6	Close sheeting	6 × 8	4	4 × 4	4 × 6	6 × 6	6 × 8	8 × 8	4	6
10 to 15	Hard	3 × 4 or 2 × 6	4	4 × 6	4	4 × 4	4 × 6	6 × 6	6 × 8	8 × 8	4	6
	Likely to crack	3 × 4 or 2 × 6	2	4 × 6	4	4 × 4	4 × 6	6 × 6	6 × 8	8 × 8		6
	Soft, sandy, filled........	3 × 4 or 2 × 6	Close sheeting	4 × 6	4	4 × 6	6 × 6	6 × 8	8 × 8	8 × 10	4	6
	Hydrostatic pressure......	3 × 6	Close sheeting	8 × 10	4	4 × 6	6 × 6	6 × 8	8 × 8	8 × 10	4	6
15 to 20	All kinds or conditions ...	3 × 6	Close sheeting	4 × 12	4	4 × 12	6 × 8	8 × 8	8 × 10	10 × 10	4	6
Over 20	All kinds or conditions ...	3 × 6	Close sheeting	6 × 8	4	4 × 12	8 × 8	8 × 10	10 × 10	10 × 12	4	6

Trench jacks may be used in lieu of, or in combination with, cross braces. Shoring is not required in solid rock, hard shale, or hard slag. Where desirable, steel sheetpiling and bracing of equal strength may be substituted for wood.

Dimensions are based on nominal sizes of Douglas fir or equivalent. The greater dimensions of the stringers should be straight angle to the sheeting.

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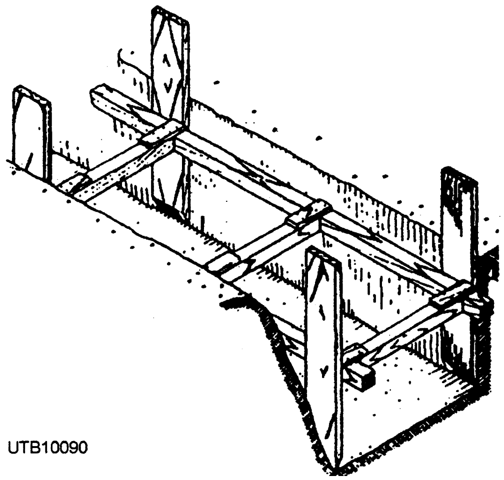

Figure 4-25.—Position of walers before placing sheetpiling for shoring trenches.

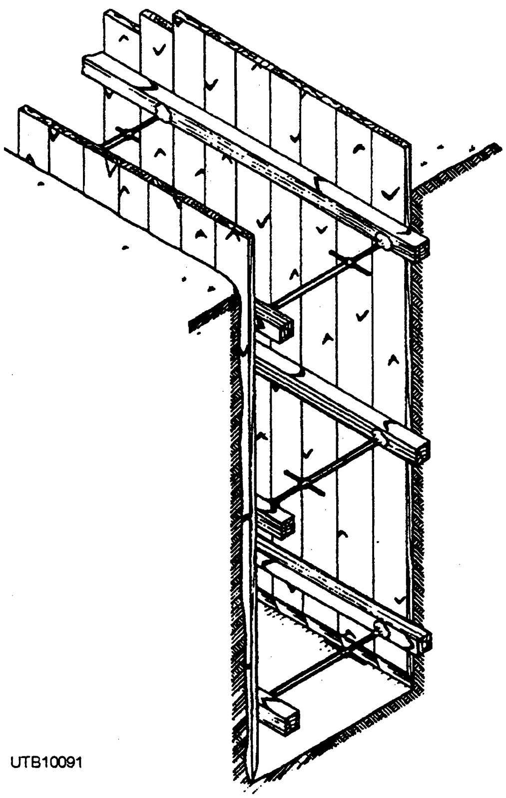

Figure 4-26.—Trench shoring with trench jacks for cross braces.

2. Bracing or shoring of trenches should be carried along with the excavation.

3. Cross braces or trench jacks should be placed in a true horizontal position, secured to revent sliding, falling, or kickouts.

4. Portable trench boxes, sliding trench boxes, or shields should be designed, constructed, and maintained

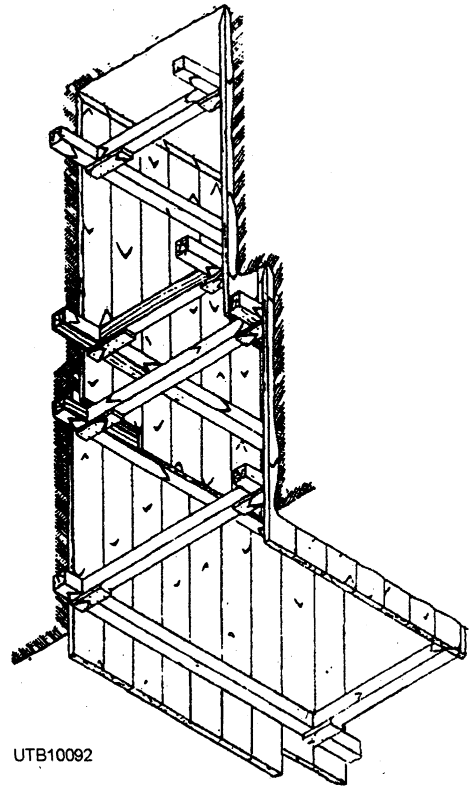

Figure 4-27.—Method of bracing when two lengths of sheetpiling are used.

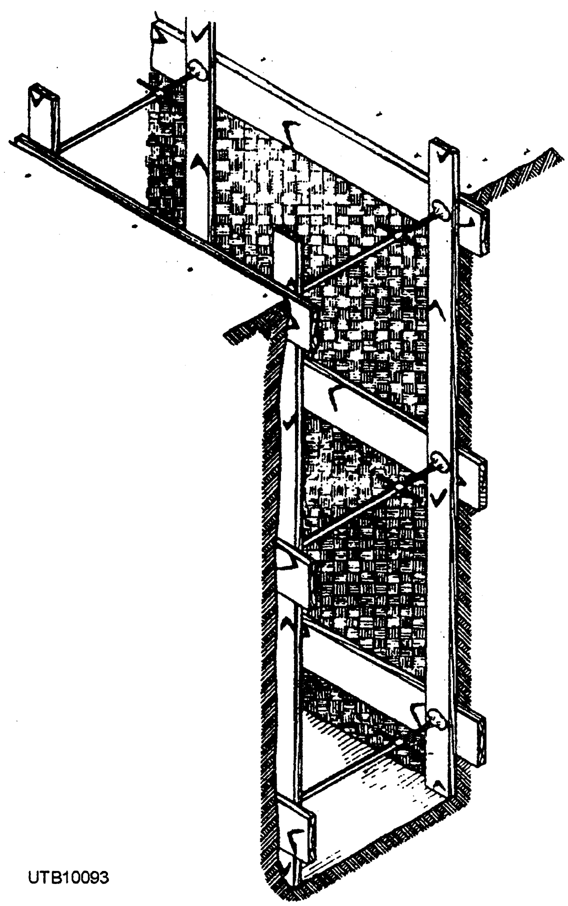

Figure 4-28.—Bracing with jack screws in hard soil.

in a manner to provide protection equal to or greater than the sheathing and shoring required for the situation.

5. Ladders used as access ways should extend from the bottom of the trench to not less than 3 feet above the surface. Lateral travel to an exit ladder should not exceed 25 feet.

6. Backfilling and removal of trench supports should progress together from the bottom of the trench. Jacks or braces should be released slowly and, in unstable soil, ropes should be used to pull out the jacks or braces from above after all personnel have cleared the trench.

7. Minimum size and spacing of timbers for shoring of trenches should be maintained according to set standards (table 4-1).

8. Aluminum hydraulic shoring should be installed according to the manufacturer's recommendations.

SCAFFOLDING

A scaffold is an elevated working platform for supporting both men and materials. It is usually temporary; its main use being in construction work. Scaffolds should be designed to support at least four times the anticipated weight of both men and materials that will use them.

Scaffolding is a structure made of wood (fig. 4-29) or of metal (fig. 4-30) to support a working platform. Built-up and suspended scaffolds may be made of wooden structural members, but steel tubing should be the first choice. This type of scaffold affords a firm, solid work platform for use by one or more men. Their lightness, mobility, and ease of erection make them most suitable for light-duty to heavy-duty work, particularly when the equipment must be erected and dismantled frequently.

Most scaffolds are in one of three primary categories: tubular, suspended, or rolling. They are also classified according to their intended use: light duty (working load must not exceed 25 pounds per square foot of platform surface), medium duty (50 pounds per square foot), and heavy duty (75 pounds per square foot).

A tabular scaffold is constructed of tubing that fits into various positions to form posts, bearers, braces, ties, and runners. A base assembly supports the posts

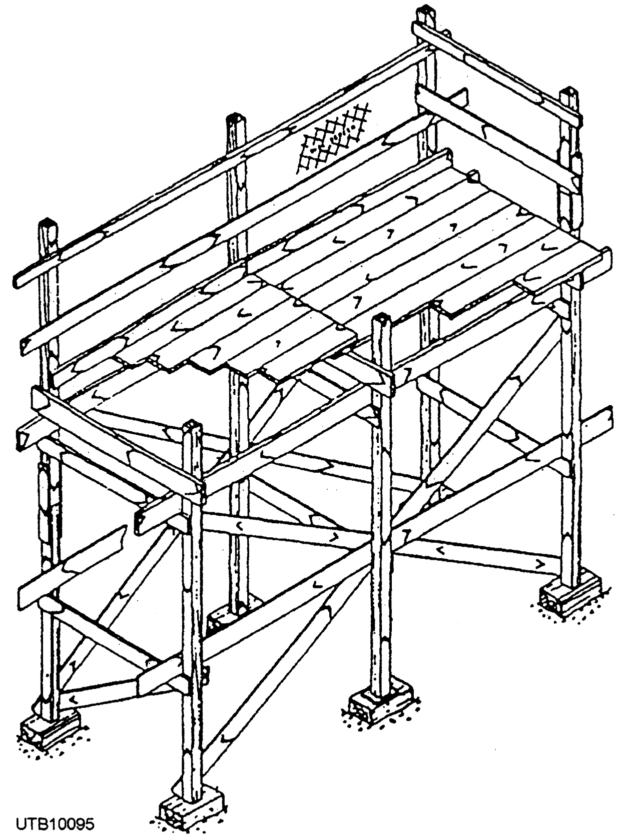

Figure 4-29.—Wood scaffold.

and special couplers that serve to connect the uprights and to join the various members (fig. 4-30).

A suspended scaffold carries a working platform on beams and ropes that is secured to structural members or to thrust outs from the structure.

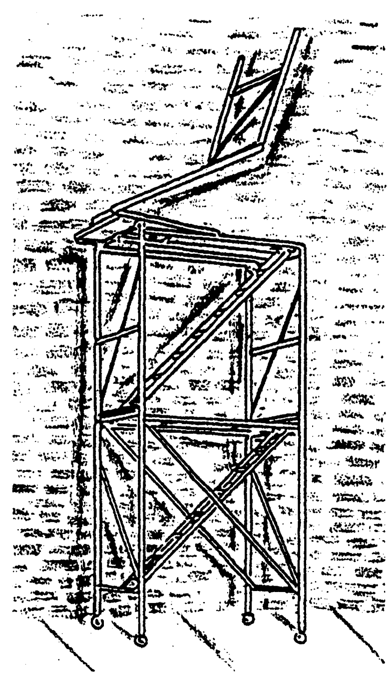

Figure 4-30.—Folding sections with fixed platforms, guard rails, and built-in stairs.

A mobile (rolling) scaffold is mounted on casters. It is constructed of a tubular-metal section of scaffolding or is made of components. designed specifically for a particular purpose (fig. 4-31).

The following are safety rules that pertain to scaffolding:

- Inspect all equipment before use.
- Inspect erected scaffolds regularly to ensure they are being maintained in a safe condition.
- Provide adequate sills for scaffold posts and use baseplates.
- Plumb and level scaffolds as erection proceeds, so the branches fit without having to be forced.
- Fasten all braces securely.
- Use and install scaffolding accessories according to the procedure recommended by the manufacturer. Do not alter accessories in the field.
- Do not ride on rolling scaffolds.
- Remove all types of material and items of equipment from the platform before attempting to move a scaffold.

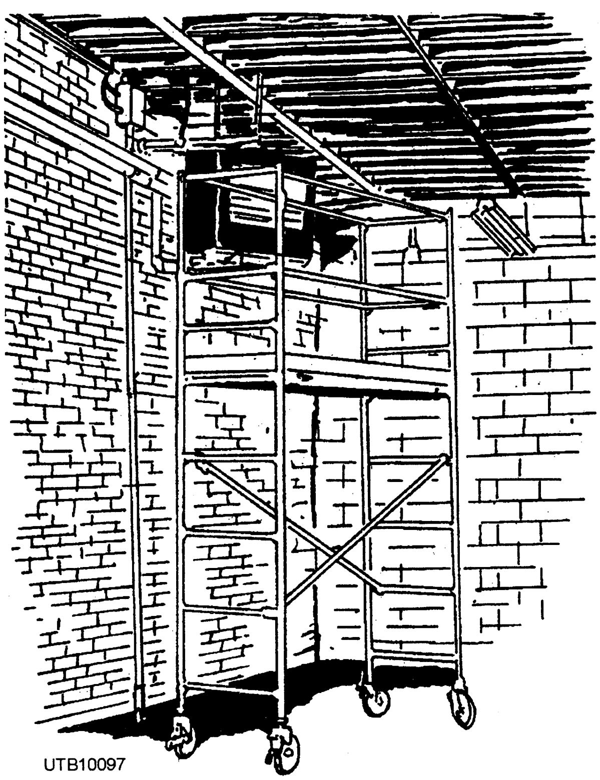

Figure 4-31.—Aluminum ladder scaffold.

Q16. Banks or sides of a trench of what height must be shored or sloped?

WASTEWATER SYSTEMS

LEARNING OBJECTIVE: *Understand wastewater component application and wastewater system installation.*

A wastewater system is a group of sewer pipes and pumps designed to convey domestic and industrial wastes and to transport them to a wastewater treatment plant (fig. 4-32). The wastewater system starts in a house or building that conveys wastewater, known as a house sewer, into a "lateral" sewer pipe. The sewer main receives wastes from two or more laterals. The trunk sewer is a large pipe that receives the flow from laterals and mains. When gravity flow is no longer practical or possible, a lift station is used to pump wastewater to a higher level. A forced main (pressure main) carries the discharge from the lift station to the main or trunk sewer. From here, the wastewater flows by gravity to an interceptor sewer, connecting into the wastewater treatment plant. An outfall sewer is a pipe that carries the treatment plant effluent to the point of final discharge.

A wastewater system safeguards the public health by preventing communicable diseases from getting into groundwater or drinking water systems. The wastewater system carries the raw wastewater to the treatment plant quickly for treatment. The wastewater system should only be carrying domestic and industrial wastes. Infiltration (leakage or seepage of water from a storm or groundwater into a sewer) should be controlled to the lowest practical limit. Good monitoring and maintenance are required to control infiltration. Too much infiltration overloads both the wastewater system and the treatment plant. The end result is not enough detention time and a washout of wastewater solids.

MATERIALS

As a Utilitiesman, you may be involved in construction of a wastewater system and in maintenance, repair, or minor replacement of sewers. The joints and seals used for each type and size of pipe are important. Leaks and breaks often occur at the joints; therefore, with fewer joints and proper seals, leaks can be reduced. The pipe chosen for the wastewater system should be based on the type of waste, the kind of soil, the estimated flow, and the weight of the backfill.

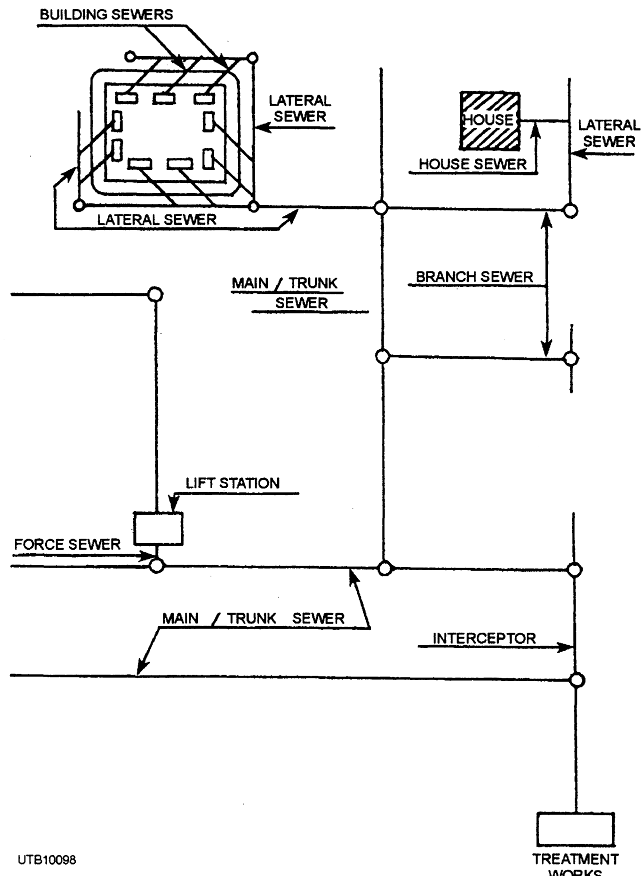

Figure 4-32.—A wastewater collection system.

Table 4-2.—Minimum Grades to Lay Sewer Lines to Maintain a Minimum Velocity of 2 Feet/Second

Pipe Size		Slope		Capacity	
Inches	CM	Inches/l00 Ft.	Cm/30.5m	Gal/Day	M^3/Day
6	15.24	7.2	18.29	260,000	984.1
8	20.32	4.8	12.19	460,000	1,741.1
10	25.4	3.4	8.63	700,000	2,649.5
12	30.48	2.6	6.60	1,000,000	3,785.0
15	38.10	1.8	4.57	1,600,000	6,056.0
18	45.72	1.4	3.56	2,300,000	8,705.5

FLOW

Wastewater systems use gravity flow to move the wastewater. Sewers should be designed to let the wastewater move at not less than 2 feet per second. Solids in the wastewater may begin to settle, and this can cause the pipe to clog and cause the wastewater to become septic. Speed of more than 8 feet per second may cause scouring and damage to the pipe. Table 4-2 shows the minimum grades to be used in laying sewer lines to provide a speed of at least 2 feet per second.

Inverted Siphon

If a part of the sewer dips below grade to avoid a railway cut, a subway, a stream, or some other object, an inverted siphon should be built in the pipe (fig. 4-33). A speed of at least 3 feet per second is needed to keep the pipe clear of settleable solids. The inverted siphon may have one, two, or more pipes. The amount of flow the siphon can handle should equal the amount of flow of the upstream system. A manhole should be placed at both ends of an inverted siphon, so it is easier to maintain the siphon.

Piers

Pipes can cross a small, shallow dip in the earth when they are supported by concrete piers. Piers require less maintenance than an inverted siphon and are less likely to make the wastewater become septic or cause other problems.

DESIGN

Knowledge of the design of a wastewater system can be of great help to you in constructing and maintaining the system. The amount of wastewater that can be carried depends on the size and slope of the pipe. Whether the system can carry certain types of industrial waste satisfactorily depends on the type of pipe being used. Sewer-use regulations should be enforced to keep toxic and corrosive wastes from getting into the system. The regulations may require grease traps in places where large amounts of grease will be wasted, sand traps where washracks and floor drains are built in, and pretreatment of some wastes. All sewer lines must be separated from potable water-supply lines. A cross-connection between the sewer and a potable waterline must never be allowed.

MANHOLES

Manholes let you inspect and clean sewer lines. Figure 4-34 shows the needed parts and sizes for a manhole. Manholes are required at points where the pipe changes direction and every 300 to 400 feet of piping. On large mains of 60 inches or more in diameter, the manholes are often spaced from 300 to 600 feet apart. The manhole should be built to keep the wastewater moving at about 2 feet per second, so the wastewater solids cannot settle in the pipe. A flow channel with a depth of three fourths of the diameter of the sewer pipe should be built in the manhole. The floor should slope toward the channel. The sewer lines and manhole must be well-aligned. If either the manhole or sewer line shifts, the pipe may break. A lid should fit tightly over the manhole. It must be strong enough to support traffic and heavy enough to keep someone other than maintenance workers from tampering with it. The lid should not be high enough to obstruct traffic nor low enough to let water build up over the lid.

LAYING PIPE

Knowledge of pipe laying can assist you in layout, performing maintenance, and making repairs. If the pipe is not installed properly, it can leak, break, or clog. The first step in installing a sewer pipe is digging the trench. The trench should be wide enough to permit proper installation of the pipe. Where shoring is required, ample allowance should be made in the width of the trench for proper working conditions. Where trenches are excavated to such a depth that the bottom of the trench forms a bed for the pipe, care should be exercised to provide solid and continuous bearing between joints, and bell holes should be provided at points where the pipe is joined. When excavated to such a depth that the bottom of the trench does not form a bed for the pipe, the trench should be backfilled to pipe grade. The bottom of the trench must also be sloped in the direction of flow, so sewage traveling through the pipeline laid in the trench is not restricted.

Trench Safety

Safety of the workers is a must when sewer lines are being laid. Signs, barricades, and lights should be installed and maintained in the area. The dirt from the trench should be piled at least 2 feet from the edge of the trench to keep it from falling back into the trench

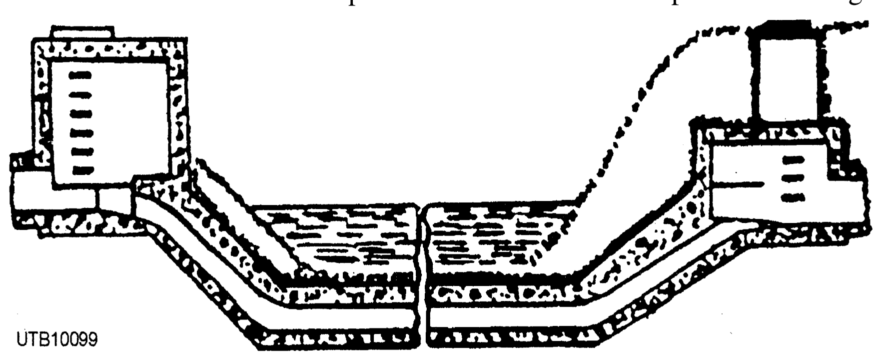

Figure 4-33.—An inverted siphon.

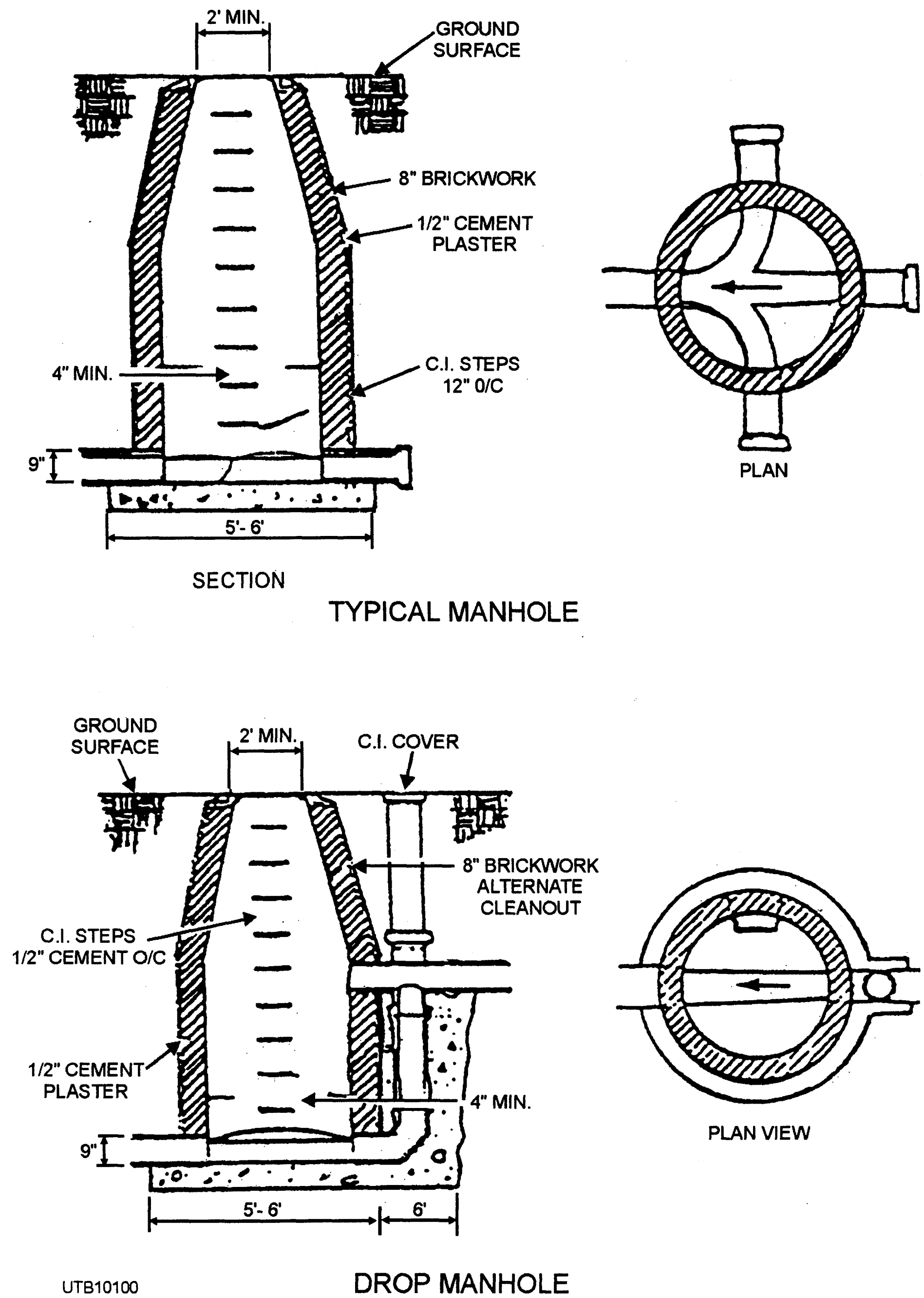

Figure 4-34.—Types of manholes.

and to allow access to the trench. If the trench is dug in unstable ground or is deeper than 5 feet, place shoring in the trench to protect workers from a cave-in.

Preparing the Trench

The pipe must be set on a well-prepared bed. The pipe should be laid with the bell ends on the upstream grade for a good joint. A small notch should be made for each bell, so the pipe will lie flat on the bed. Where rock is encountered, it should be removed to a point at least 3 inches below the grade line of the trench, and the trench should be backfilled with sand tamped in place to provide a uniform bearing for the pipe between joints. Care should be exercised, so the pipe does not rest on rock at any point including the joints. If materials of inadequate bearing are found at the bottom of the trench, stabilization should be achieved by overexcavating to solid bearing and bringing up to pipe grade by the use of sand, crushed stone, or a concrete foundation. Such a foundation should be bedded with sand tamped in place to provide a uniform bearing for the pipe between joints. The trench should be backfilled in layers of 6 inches. Until the crown of the pipe is covered by at least 2 feet of tamped earth, considerable care should be exercised in backfilling trenches. Loose earth free of rocks, broken concrete, frozen chunks, and other rubble should be placed in the trench carefully in 6-inch layers and tamped in place. Care should be taken to compact the backfill under and beside the pipe to be sure the pipe is supported properly. Backfill should be placed evenly on both sides of the pipe and tamped to retain proper alignment. The rest of the trench can be filled using heavy equipment.

SERVICE CONNECTIONS

Service connections, or house sewers (the lines from the house to the street lateral), are often built with concrete, cast iron, or plastic pipe. They should not be smaller than 4 inches in diameter. If a Y or a T branch is not built in at the point where a connection needs to be made, the Y or T saddles can be used. When you are tapping a sewer, extreme care should be taken to prevent breaking the pipe. Ensure the saddle fits well and is cemented firmly to the main line to prevent infiltration. This also helps to keep out roots from trees and other plants. Service connections must not be made by breaking into the pipe. This makeshift method is not watertight and often causes severe damage to the pipe.

Q17. To maintain a 2-foot slope, you must ensure that a 10-inch-diameter pipe has a minimum drop of how many inches per foot?

Q18. Manholes are required every 300 to 400 feet and at what other point on a main sewer line?

WATER DISTRIBUTION SYSTEM

LEARNING OBJECTIVE: *Identify water distribution system elements and installation.*

The last section of this chapter explains the procedures to be followed for providing a water source. The water-supply system for a building starts from a single source: the water main. In this section, tapping a water main to install a corporation stop and the elements that go into a water distribution system are discussed.

After the trench is dug to the main water line, a corporation stop (view A, fig. 4-35) can be installed while the main is under pressure by using the water main self-tapping machine shown in view B, figure 4-35. A 1-inch tap is the largest opening that can be made while the main is under pressure. Ninety pounds is the maximum pressure that can be tapped against it with a water-tapping machine. You must understand the operation of the machine before attempting to tap a main under pressure. The tap should be located as near to the top of the water main as possible. Clean the rust and dirt from the main at the point where the tap is to be made. Place the machine gasket on the main and mount the tapping machine over the gasket by wrapping the tie chain around the main.

NOTE

Ensure the saddle and the chain are of the correct size. If you attempt to use the incorrect size, the main will cock and the tap will cross thread.

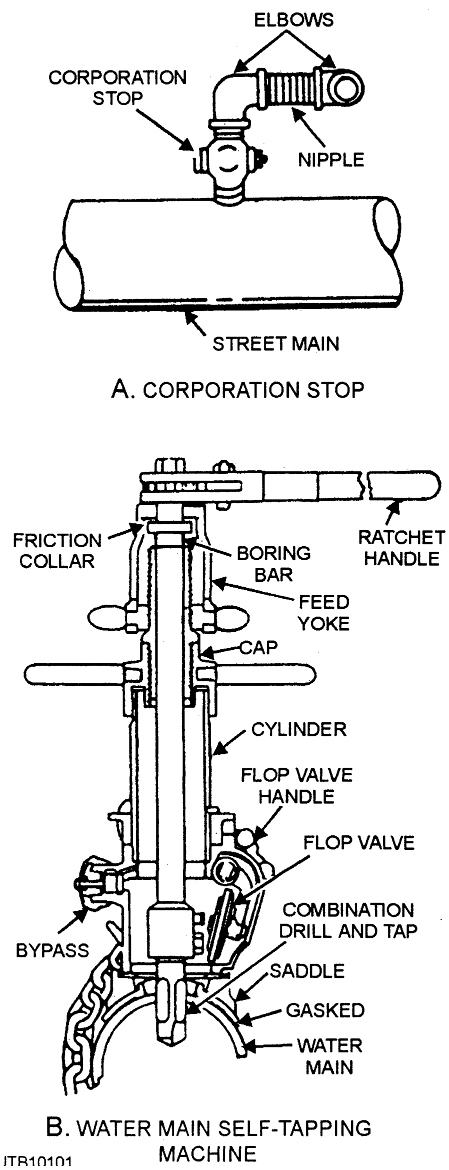

Figure 4-35.—Corporation stop and self-tapping machine.

Tighten the chain mounting bolts until a solid, watertight connection is formed between the main and the base of the machine. Check the depth adjustment on the boring bar, and insert the proper size drill and tap into the holder. Assemble the machine by inserting the boring bar through the cylinder and tightening the cap. Start drilling the hole by applying pressure at the feed yoke while operating the ratchet handle. After the drill penetrates the main, the boring bar turns easily until the tap starts cutting threads. When the tap starts threading the hole, back off of the feed yoke to prevent the threads in the main from stripping. Continue to turn the boring bar until the depth adjustment hits the stop. You have hit the stop when the ratchet handle tightens and it can no longer be tightened without undue force. To remove the tap from the hole, reverse the ratchet and back the boring bar out by turning it counterclockwise. When the boring bar is raised high enough to clear the bottom of the cylinder, close the flop valve. Check to see that the bypass valve is closed. This prevents water from entering the cylinder. The water under pressure from the main is now trapped in the base of the machine, and the boring bar can be removed by unscrewing the machine cap. Remove the drill and tap tool and install a corporation stop of the proper size in the end of the boring bar. Be sure the handle of the corporation stop is in the CLOSED position. Reinstall the boring bar in the cylinder and tighten the cap. Open the bypass valve to allow the water-main pressure into the cylinder, so the flop valve can be opened again. The corporation stop can now be screwed into the main by turning the boring bar. Since the corporation stop was closed before being installed, the only noticeable water leak from the operation is from the water trapped in the cylinder of the machine. Release the water pressure from the cylinder by opening the bypass valve and removing the boring bar. Disengage the chain from the main and remove the machine. Check for leakage around the corporation stop. If the corporation stop leaks, tighten it with an adjustable jaw wrench.

DISTRIBUTION SYSTEM ELEMENTS

The elements of a distribution system include distribution mains, arterial mains, storage reservoirs, and system accessories (including booster stations, valves, hydrants, main-line meters, service connections, and backflow preventers).

Distribution mains are the pipelines that make up the distribution system. Their function is to carry water from the water source or treatment works to users.

Arterial mains are large-size distribution mains. They are interconnected with smaller distribution mains to form a complete gridiron system.

Storage reservoirs are structured to store water. They may serve to equalize the supply or pressure in the distribution system.

System accessories include the following:

- Booster stations that pump water from storage or a relatively low-pressure main to the distribution system, or it may serve a portion of the system that is at a higher elevation.
- Valves that serve to control the flow of water in the distribution system by isolating areas for repair or by regulating system flow or pressure.
- Hydrants that are designed to allow water from the distribution system to be used for fire-fighting purposes.
- Main-line meters that serve to record the flow of water in a part of the distribution system.
- Service connections that connect either an individual building or other plumbing system to the distribution-system mains.
- Backflow preventers that protect the water source from contamination.

SYSTEM LAYOUT AND SIZE

When distribution systems are carefully planned, the pipes are usually laid out in a grid or belt system. A network of large pipes divides the community or base into areas of several blocks each (fig. 4-36). The streets within each area are served by smaller pipes connected to the larger ones. When possible, the network is planned so the whole pipe system consists of loops, and no pipes come to a dead end. In this way, water can flow to any point in the system from two or more directions; hence, the water supply need not be cut off for maintenance work or a break in a pipe.

Older water systems frequently were expanded without planning and developed into a treelike system. This consists of a single main that decreases in size, as it leaves the source and progresses through the area originally served. Smaller pipelines branch off the main and divide again, much like the trunk and branches of a tree. A treelike system is not desirable because the size of the old main limits the expansion of the system needed to meet increasing demands. Also, there are many dead ends in the system where

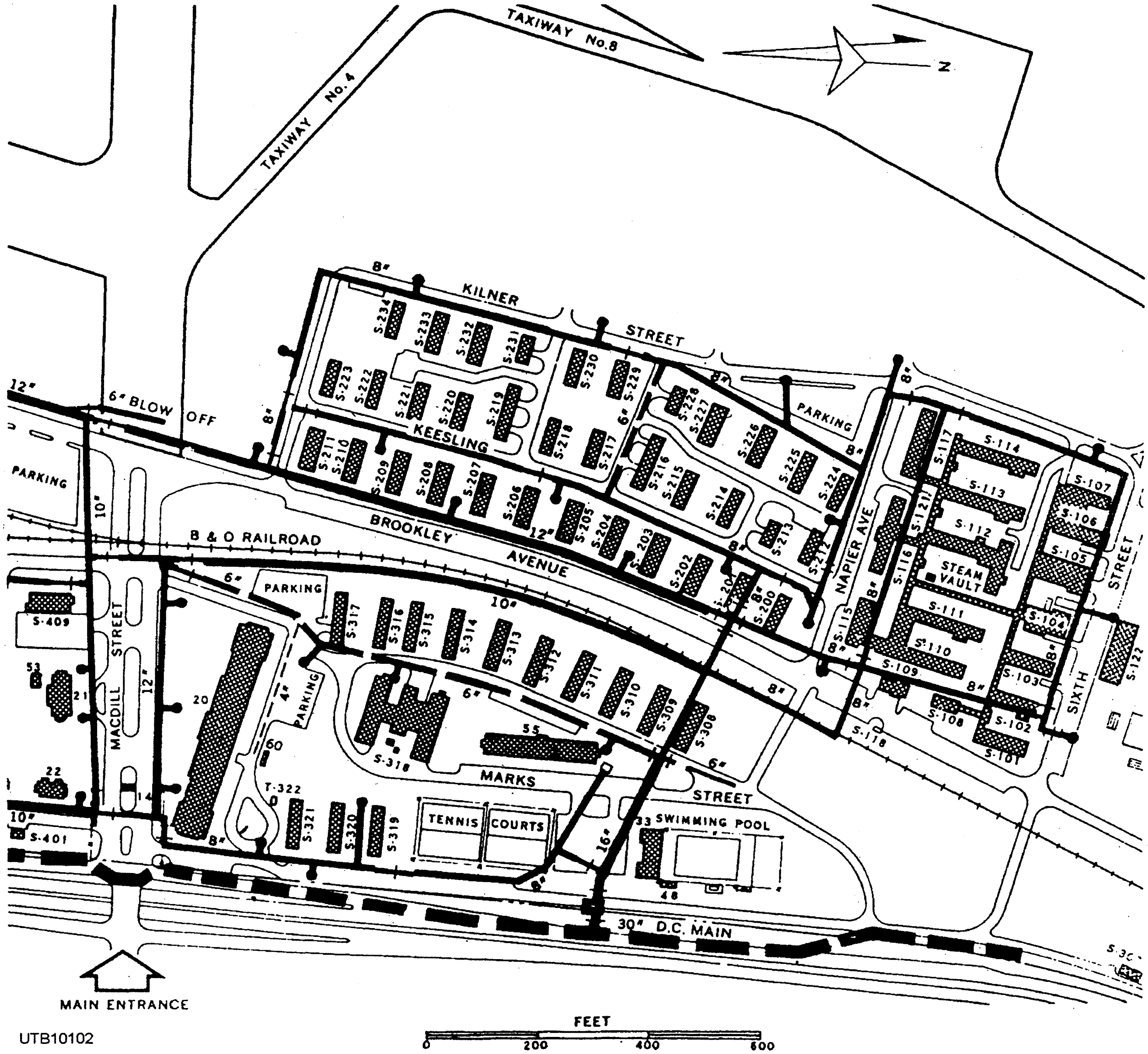

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Figure 4-36.—Distribution system layout.

water remains for long periods of time, causing undesirable tastes and odors in nearby service lines.

MAIN LOCATION

Mains should be located along streets to provide short hydrant branches and service connections. Mains should not be located under paved or heavily traveled areas. They should be separated from other utilities to ensure the safety of potable water supplies, so the maintenance of one utility causes a minimum of interference with other utilities.

VALVE LOCATION

The purpose of installing shutoff valves in water mains at various locations within the distribution system is to allow sections of the system to be taken out of service for repairs or maintenance without significantly curtailing service over large areas. Valves should be installed at intervals not greater than

5,000 feet in long supply lines and 1,200 feet in main distribution loops or feeders. All branch mains connecting to feeder mains or feeder loops should have valves installed as close to the feeders as practical, so branch mains can be taken out of service without interrupting the supply to other locations. In the areas of greatest water demand or when the dependability of the distribution system is particularly important, maximum valve spacing of 500 feet may be appropriate. At intersections of distribution mains, the number of valves required is normally one less than the number of radiating mains; the valve omitted from the line is usually the one that principally supplies flow to the intersection. Valves are not usually installed on branches serving fire hydrants on military installations. As far as practical, shutoff valves should be installed in standardized locations (that is, the northeast corner of an intersection or a certain distance from the center line of a street), so they can easily be found in emergencies. For large shutoff valves (approximately 30 inches in diameter and larger), it may be necessary to surround the valve operator or entire valve with a vault to allow for repair or replacement. In important installations and for deep pipe cover, pipe entrance access manholes should be provided so valve internal parts can be serviced. When valves, vaults, or access manholes are not provided, all buried valves, regardless of size, should be installed with special valve boxes over the operating nut to permit operation from ground level by the insertion of a special long wrench into the box.

HYDRANT LOCATION

Proper clearance should be maintained between hydrants and poles, buildings, or other obstructions, so the hose lines can be readily attached and extended. Generally, hydrants are located at least 50 feet from a building and in no case are they located closer than 25 feet to a building, except where building walls are blank fire walls. Hydrants may be located adjacent to blank portions of substantial masonry walls where the chance of falling walls is remote.

Street intersections are the preferred location for fire hydrants because fire hoses can then be laid along any of the radiating streets. However, the likelihood of vehicular damage to hydrants is greatest at intersections, so the hydrants must be carefully located to reduce the possibility of damage. Hydrants should not be located less than 6 feet nor more than 7 feet from the edge of a paved roadway surface. When hydrants exceed this distance, consider stabilizing or surfacing a portion of the wide shoulders adjacent to the hydrants to permit connection of the hydrant and pumper with a single 10-foot length of suction hose. In some circumstances, it may not be practical to meet this criteria. Then try not to exceed 16 feet (two sectons of hose) to the pumper.

Hydrants should not be placed closer than 3 feet to any obstruction nor in front of any entranceway. The center of the lower outlet should not be less than 18 inches above the surrounding grade, and the operating nut should not be more than 4 feet above the surrounding grade.

In aircraft fueling, mass parking, servicing, and maintenance areas, the tops of hydrants must not be higher than 24 inches above the ground with the center of the lowest outlet not less than 18 inches above the ground. The pump nozzle should face the nearest roadway.

SAFETY PROCEDURES

Here are rules for plumbing safety.

1. Keep the job clean.
2. Pick up scrap pieces of pipe.
3. Keep all tools and materials off the job when not in use.
4. Keep the shop floors dry and clean.
5. Keep the stockpiled materials carefully braced and blocked to prevent falling.
6. Lift with your legs, not your back.
7. Use pipe tongs for carrying heavy pipe sections.
8. Use proper tools for the job at hand.
9. Keep tools in good condition.
10. Use care in handling torches and hot lead.
11. Do not pour hot lead into a wet joint.
12. Use safety goggles, when required.
13. After installing fixtures, test the pipes for 1eaks and proper drainage before leaving the job

Q19. Hydrants should be located what distance from buildings?

Q20. The top of a hydrant must not be higher than how many inches above the ground?